Curriculum Framework for Four Year Undergraduate Programme
PHYSICS
Under NEP-2020

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Board of Studies (Physics)
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1.0 Introduction & Background

In ancient India, education was primarily delivered through the Gurukul system, a traditional residential mode of learning where students (Shishyas) lived with their teacher (Guru). This setup emphasized a holistic approach, integrating spiritual, practical, and intellectual training. Education in a Gurukul covered a broad range of subjects including the Vedas, Upanishads, grammar, mathematics, astronomy, medicine, and the arts. The learning process involved memorization, recitation, debate, and hands-on application. Esteemed institutions like Nalanda, Takshashila, and Vikramashila evolved from this tradition, becoming key centers of learning that excelled in diverse subjects. Their curriculum balanced theoretical knowledge with practical experience, fostering a comprehensive educational environment that promoted innovation and the development of new ideas. Many Shishyas and Gurus made pioneering contributions to fields of mathematics, astronomy, and medicine from there learning centers. Notable scholars like Aryabhata introduced the concept of zero and explained Earth's rotation, while Brahmagupta developed rules for zero and negative numbers. Varahamihira made significant advancements in astronomy and weather prediction, and Sushruta's contributions to surgery and anatomical knowledge reflect the scientific sophistication of the era. These achievements, documented in seminal texts such as Aryabhatiya, Brahmasphutasiddhanta, and Sushruta Samhita, laid foundational principles that not only advanced Indian science but also influenced global developments in these disciplines.

During the medieval period, along with the Gurukul systems, Islamic education emerged in India through madrasas and maktabs, emphasizing religious studies, Arabic, Persian, mathematics, and astronomy. The Mughal era, especially under rulers like Akbar, facilitating a fusion of Islamic and Indian educational traditions, nurturing a diverse intellectual milieu.

The advent of British colonial rule in the 18th century signified a notable transition towards Western-style education, with early initiatives by Christian missionaries and the East India Company primarily focused on training clerks and administrators. The 19th-century Anglicist-Orientalist debate spurred a preference for English-medium instruction, notably advocated by Macaulay's Minute in 1835, further institutionalized through Wood's Despatch (1854), which laid the groundwork for a structured education system spanning primary, secondary, and higher education. The establishment of universities in Calcutta, Bombay, and Madras in 1857 formalized the framework for higher education in India.

Post-independence, the Indian education system underwent significant reforms aimed at democratizing access, enhancing quality, and fostering socio-economic development. Initiatives included the establishment of the University Education Commission (UGC) in 1956 to regulate higher education. The Kothari Commission (1964-66) provided a comprehensive blueprint for the educational structure followed by the National Education Policy of 1968 which was the first comprehensive policy framework for education in independent India. It emphasized a common school system, the three-language formula, and the promotion of science and regional languages to ensure equitable and quality education across India. It also aimed to expand educational access, particularly for marginalized groups, and modernize the curriculum to address contemporary needs. Later, the National Policy on Education (NPE) of 1986 ushered in a new phase, focusing on universal access, quality improvement, and vocational training. It emphasized institutional autonomy and accountability, setting the stage for modernization, internationalization, and innovation to elevate India's higher education to global standards. This policy laid the foundation for later educational reforms, including the 1992 revision, and influenced efforts to universalize education while integrating vocational and technological advancements. Initiatives like Operation Blackboard sought to improve primary school infrastructure, while the Sarva Shiksha Abhiyan (2001) aimed to universalize elementary education. The Right to Education Act (2009) legally mandated free and compulsory education for children aged 6 to 14, reinforcing the commitment to inclusivity and equity.

To prepare students for the complex and dynamic challenges of the 21st century, the National Education Policy (NEP) 2020, unveiled by the Government of India in 2020**.** This policy introduces a series of fundamental changes aimed at fostering a more holistic and multidisciplinary approach to education. NEP 2020 reflects a continuous effort to adapt and reform in the trajectory of Indian education system from ancient gurukuls to modern universities. By envisioning a forward-looking and inclusive educational framework, it aspires to prepare India's youth for the demands of a globalized world.

2.0 National Education Policy 2020 (NEP 2020)

The global education development agenda, as outlined in Goal 4 (SDG4) of the 2030 Agenda for Sustainable Development, adopted by India in 2015, sets a profound mission: to ensure that "inclusive and equitable quality education and lifelong learning opportunities" are accessible to all by the year 2030. To lay the groundwork for achieving all essential targets and objectives, needs of innovative approaches, robust policies, and collaborative efforts to transform the educational landscapes of India. Keeping in view this as well as to make a significant overhaul the Indian education system, the Government of India introduced the National Education Policy (NEP) 2020 on 29 July 2020.

The National education policy 2020(NEP2020) refers to the set of principles, guidelines, and initiatives that a country adopts to shape its educational system and ensure the provision of quality education to its citizens. It is a comprehensive framework for the transformation of the education system in India and air to address the challenges and shortcomings of the existing education system and provide a vision for the future of education in India. NEP 2020 also envisions a comprehensive transformation of higher education in India focusing on multidisciplinary and holistic learning.

Restructuring the education system into a 5+3+3+4 framework and integration of vocational education from the school level to higher education are the major reformations proposed by NEP 2020. NEP2020 is also focus to provide Choice and flexibility to the student at each level of study. Students can choose their academic pathway during their study to get a certificate, diploma, and degree. Flexible learning is important to choose one's academic pathway leading to the award of certificate, diploma, and degree. There are occasions when learners have to give up their education mid-way for various reasons and the records of the clearance of credits for such incomplete academic programmes remain unaccounted. Such rigid boundaries are attempted to remove to ensure zero-year-loss to students in the event of exiting in between in his/her academic progression. It will reduce the drop-out rate, thus improving Gross Enrolment Ratio (GER), which is one of the major objectives of the National Education Policy, (NEP), 2020.

For the accomplishment of these objectives, four-year undergraduate program with multiple entry and exit systems is proposed which represents a significant shift in Indian higher education, aiming to make it more flexible, holistic, and aligned with global standards. Specifically, for disciplines like Physics, the FYUP under NEP 2020 offers a comprehensive and in-depth understanding of the subject, integrated with research and practical experience. Moreover, by fostering a multidisciplinary approach and offering multiple exit options, the program is designed to cater to diverse student needs and career aspirations.

3.0 Four Year Under Graduate Programme (FYUP) in Physics

In the dynamic world of physics, where curiosity meets discovery and imagination merges with innovation, the Four-Year Undergraduate Programme (FYUP) in Physics under NEP2020 is meticulously crafted. Rooted in the belief that the essence of physics lies in the relentless pursuit of knowledge and the unyielding spirit of exploration, this programme is designed to ignite curiosity, foster creativity, and nurture a deep appreciation for the wonders of the universe.

The Four-Year Undergraduate Programme (FYUP) in Physics epitomizes a dedication to furnishing students with a profound grasp of the fundamental principles governing the natural world. Spanning from classical mechanics to quantum theory, it propels students on an odyssey of exploration, delving into the enigmatic realms of matter, energy, space, and time. This voyage is facilitated through a blend of theoretical inquiry, practical experimentation, and immersive research, urging students to engage in critical analysis, unravel complex phenomena, and redefine the frontiers of human comprehension. Moreover, the FYUP fosters a vibrant culture of innovation and entrepreneurship, urging students to leverage their knowledge to tackle real-world challenges and forge pioneering solutions. Designed with adaptability in mind, the programme empowers students to tailor their academic trajectory to match their individual interests and ambitions. With a diverse array of elective courses, interdisciplinary ventures, and hands-on learning opportunities, students are afforded the liberty to explore uncharted territories, deepen their expertise, and chart their own course within the realm of physics.

Furthermore, the FYUP presents students with invaluable opportunities to immerse themselves in cutting-edge research initiatives, collaborating closely with esteemed faculty members to contribute to the advancement of scientific knowledge. This hands-on involvement not only nurtures a spirit of inquiry but also equips students with practical skills and insights that are invaluable for their future endeavours.

In brief, FYUP in Physics offers a flexible, interdisciplinary curriculum, integrating theoretical knowledge with practical skills and research. Students can choose electives across various disciplines and engage in advanced research projects in their final year. With multiple exit options, continuous assessment, and a focus on global standards, the program prepares students for diverse career paths and higher studies. The main features of FYUP in Physics are –

(a) **Holistic Learning Experience**: FYUP in Physics offers a holistic and comprehensive curriculum that blends theoretical foundations with practical applications, preparing students for both advanced studies and diverse career opportunities.

(b) **Flexible and Interdisciplinary:** Offers flexibility through elective courses in mathematics, computer science, and engineering, allowing students to tailor their education to their interests and career goals.

(c) **Skill Development and practical training:** The program integrates laboratory work, internships, and real-world problem-solving, equipping students with practical skills essential for scientific research and industry roles. Courses on computational physics, instrumentation, and data analysis prepare students for modern technological challenges.

(d) Multiple Exit Options: Students can exit after 1, 2, or 3 years with a certificate, diploma, or bachelor's degree respectively, or continue to the fourth year for a Bachelor's degree with Research.

(e) Global Alignment: The FYUP aligns with global educational frameworks, making physics graduates more competitive in international academic and professional arenas.

(f) Emphasis on Research: The fourth year focuses on research, allowing students to undertake substantial projects or theses in areas like quantum mechanics, astrophysics, or material science, enhancing their analytical and experimental skills.

(g) Career and Higher Education Pathways: Graduates can pursue careers in academia, research institutes, technology firms, or continue their studies with postgraduate degrees in physics or related fields.

4.0 Multiple Entry and Exit in FYUP in Physics

The multiple entry and exit system in Physics provides an inclusive, flexible, and learner-centered educational environment to the learners that accommodates diverse learning needs and actively promotes lifelong learning. This system allows students to join the program at various stages and exit with recognized qualifications, including certificates, diplomas, and bachelor's degrees, depending on their educational goals and circumstances. It accommodates diverse learners, including those with prior academic credits or professional experience, facilitating seamless integration into the program. Moreover, it empowers learners to take control of their educational journey, providing them with the flexibility to tailor their studies according to their interests, pace, and personal commitments. This learner-centric approach not only enhances student engagement and satisfaction but also cultivates a culture of continuous learning beyond traditional academic boundaries. Overall, Multiple Entry and Exit in FYUP in Physics reflects a student-centered paradigm shift, empowering individuals to chart their educational pathways and achieve their aspirations in a flexible and supportive environment. The objectives of multiple entry and exit are

(i) **Flexibility:** Multiple entry and exit options provide learners with greater flexibility to pursue education at their own pace and according to their individual circumstances. It allows students to take breaks, re-enter education when ready, or switch between different learning pathways without losing their progress. It offers flexibility in curriculum and novel course options to students in addition to discipline specific specializations and offer creative combinations of disciplines of study in his/her academic journey. Thus removes the rigid boundaries and facilitate new possibilities for learners

(ii) **Inclusive Education:** By offering multiple entry and exit points, education systems aim to be more inclusive and accommodate diverse learner profiles. It provides opportunities for individuals who may not be able to commit to a full-length course or program, such as working professionals, adult learners, or individuals with specific needs or responsibilities.

(iii) **Lifelong Learning:** Multiple entry and exit points promote the concept of lifelong learning by enabling individuals to acquire qualifications and certifications incrementally. It encourages continuous skill development and facilitates re-skilling or up-skilling throughout a person's life, adapting to the evolving needs of the workforce and society.

(iv) **Recognition of Prior Learning:** Implementing multiple entry and exit options acknowledges the knowledge and skills individuals have acquired through informal or non-traditional learning experiences. It allows learners to receive recognition for their prior learning and integrate it into formal education pathways, minimizing duplication of efforts and promoting efficiency.

(v) **Credit accumulation and transfer:** Credit accumulation and transfer refer to the process of recognizing and transferring academic credits earned by students from one educational institution to another. This concept allows students to continue their education seamlessly, either by transferring to another institution or by re-entering education after a break, without losing the credits they have already earned using Academic Bank of Credit (ABC). It also facilitates encashing credits earned when the learner resumes his/her programmes of study.

(vi) **Improved Gross Enrolment Ratio (GER):** By removing rigid barriers and providing alternative pathways, multiple entry and exit provisions aim to enhance Gross Enrolment Ration (completion rates) in Higher Education Institute (HEI). It reduces dropout rates and increases the likelihood of individuals successfully completing their educational goals, as they have the flexibility to adapt their learning journey according to their needs and circumstances.

4.1 Operational Details:

The multiple entry and exit system within the FYUP in Physics aimed to facilitate smooth transitions and foster personalized learning journeys of Physics tailored to each student's unique needs and aspirations. Every aspect of the system is carefully crafted to ensure that students can seamlessly navigate their educational pathway, whether they choose to enter the program at its inception or join at later stages. By offering a range of exit options at different intervals, the system acknowledges the diverse academic trajectories and career objectives of students, providing them with formal qualifications commensurate with their accomplishments. Through its emphasis on flexibility, adaptability, and individualized support, the operational details of the multiple entry and exit system within the FYUP in Physics reflect a commitment to student-cantered excellence and the promotion of lifelong learning in a dynamic academic environment. To enable multiple entry and exit points in the FYUP in Physics, qualifications such as certificates, diplomas, and degree are organized in a series of levels in an ascending order from NCrF level 4.5 to level 6.

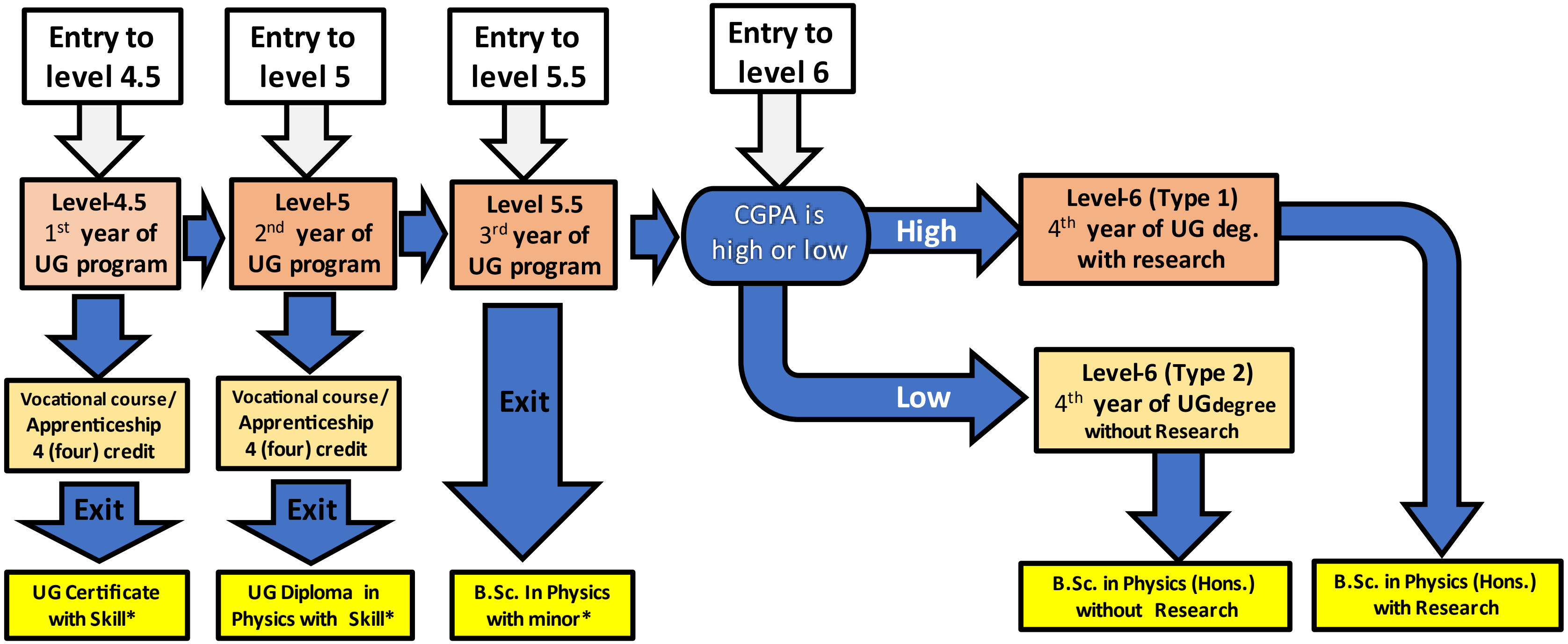

Figure 1: Multiple Entry and Exit in FYUP

1st Year of FYUP in Physics (NCrF Level 4.5):

Entry 1: The Secondary School Leaving Certificate (Level 4.0) with Physics and Mathematics as the two essential subjects is the prerequisite for admission to Level 4.5 of FYUP in Physics. Entry into the first year of FYUP in Physics (Level 4.5) is open to those who met the specific requirements as par admission regulations of Rajiv Gandhi University. Final admission to Four Year Under Graduate Programme (FYUP) in Rajiv Gandhi University and its affiliated colleges is based on the evaluation of documentary evidence (including the academic record) of the applicant's ability to undertake and complete a FYUP in Physics.

Exit 1: When a student wants to exit after the successful completion of 1st Year of FYUP he/she has to secure 4 credits in work based vocational courses offered during summer term or internship /Apprenticeship in addition to 6 credits from Skill Enhancement Courses (SEC) earned during first and second semester. A certificate is awarded to the student on the skill he/she has achieved.

2nd Year of FYUP in Physics (NCrF Level 5.0):

Entry 2. The entry requirement for Level 5.0 (2nd year of FYDP) is a UG certificate obtained after completing the first year (two semesters) of the FYUP. This entry is open within the three years of successful completion of his/her UG certificate in a higher education institute. This entry in the 2nd Year of FYUP in a particular discipline based on the evaluation of documentary evidence (including the academic record) of the applicant's ability to undertake and complete a FYUP in Physics. The students who have met specified levels of attainment and the requirements as per admission regulations of Rajiv Gandhi University are only allowed to entry at this level of FYUP in Physics.

Exit 2: When a student wants to exit after the successful completion of 2nd Year of FYUP, he/she has to secure 4 credits in work/skill based vocational courses offered during first year or second year summer term. The student will be awarded a undergraduate diploma in Physics with the skill he/she achieved.

3rd Year of FYUP in Physics (NCrF Level 5.5):

Entry 3. The entry requirement for Level 5.5 is a UG diploma in Physics obtained after completing two years (four semesters) of the undergraduate programme in a higher education institute. Such an entry in the 3rd Year of FYUP in a particular discipline based on the evaluation of documentary evidence (including the academic record) of the applicant's ability to undertake and complete a FYDP in Physics. The students who have met specified levels of attainment and the requirements as per admission regulations of Rajiv Gandhi University are only allowed to entry at this level of FYUP in Physics.

Exit 3: On successful completion of three years, the student will be awarded with UG Degree in Physics i.e Bachelor of Science in Physics.

***4th Year* of FYUP in Physics (NCrF Level 5.5):**

Entry 4: An individual seeking admission to a Bachelor's degree (Honours/Research) (Level 6.0) in Physics would normally have completed all requirements of the relevant three-year bachelor degree (Level 5.5). After completing the requirements of a three-year Bachelor's degree, students have to choose Bachelor degree with two between two option (i) UG degree with Research and (ii) UG degree without Research. The entry criteria for these two choices are as per the regulations of Rajiv Gandhi University.

(a) ***UG degree with Research:*** To make entry to this option students have to fulfil the minimum eligibility criteria i.e., CGPA 7.5 up to 6th semester along with the positive review report of the debarments as per the guidelines.

(b) ***UG degree without Research:*** All the students who have successfully completed up to 6th semester of UG Program can enrol and continue studies in the UG degree without Research.

Exit 4: A student who successfully completes the fourth year will receive either a Bachelor's degree (Honours) with Research or a Bachelor's degree (Honours) without Research, depending on how they are enrolled in the fourth year of undergraduate study. Students who have successfully completed all the requirements of Level 6.0 with Research will be awarded B.Sc. Physics (Hons.) with Research while those who have complected the requirements without Research will be awarded B.Sc. in Physics without Research.

Table 1: Qualification Type and Credit Requirements in FYUP

Levels	Qualification title	Credit requirements
Level 4.5 (1st year)	***Undergraduate Certificate*** (In the field of learning/discipline with skill*) • for those who exit after the first year (two semesters) of FYUP • Programme duration: first year or two semesters of FYUP • Awarded certificate in the skill-based courses and the internship/ Apprenticeship he/she has successfully complected.	Minimum 42 from the regular courses and additional 4 credits in work based vocational courses offered during summer term or internship/ Apprenticeship
Level 5.0 (2nd year)	***Undergraduate Diploma*** • for those who exit after the second year (four semesters) of FYUP • Programme duration: two year or four semesters of FYUP • Awarded Diploma in Physics courses with the skill he/she has achieved.	Minimum 80 from the regular courses and additional 4 credits in work based vocational courses offered during summer term or internship/ Apprenticeship
Level 5.5 (3rd year)	***Bachelor' Degree*** • for those who exit after the Third year (Six semesters) of FYUP • Programme duration: Three years or six semesters • Awarded B.Sc. in Physics	Minimum 120 from the regular courses
Level 6.0 (4th year)	***Bachelor' Degree (Hons)*** **:** • for those who exit after the Fourth year (Eight semesters) of FYUP • Awarded B.Sc. in Physics (Hons.) with Research or B.Sc. in Physics (Hons.) without Research	Minimum 160 from the regular courses

5.0 Program Education Objectives of FYUP in Physics

The PEOs are broad statements that describe the career and professional accomplishments that the program is preparing its graduates to achieve in a few years after receiving the degree. The PEOs of B.Sc. in Physics/ B.Sc. in Physics (Hons.) are as follows:

PEO-1: To prepare science graduates to exhibit quality of excellence, critical thinking, creativity, inventiveness, and self-motivation for life-long learning to handle all kind of diverse situations in interdisciplinary and multidisciplinary environment.

PEO-2: To produce graduates who are globally acceptable professionals for government, corporate and research organizations along with skills for entrepreneurial pursuits in multidisciplinary areas.

PEO-3: To groom graduates who can demonstrate technical competence in the field of Physics and develop solutions to the complex problems.

PEO-4: To produce graduates who can ethically lead and work as a part of team towards the fulfilment of both individual and organizational goals.

PEO-5: To engage graduates in professional pursuits to enhance their own achievements along with serving the society at large.

PEO-6: To enable the graduates to pursue higher education in physics and allied domains.

6.0 Program Outcomes of FYUP in Physics

Embedded within the curriculum are Program Outcomes (PO) and Programme Specific Outcomes (PSO), which serve as guiding principles to ensure holistic development and attainment of essential skills and knowledge.

Program Outcomes (POs) are attributes of the graduates of the program that are indicative of the graduates' ability and competence to work as science professional upon graduation. Program Outcomes are statements that describe what students are expected to know or be able to do by the time of graduation. They must relate to knowledge and skills that the students acquire from the program. The achievement of all outcomes indicates that the student is well prepared to achieve the program educational objectives down the road.

POs are overarching statements that describe what students are expected to know, understand, and be able to do by the time they complete a particular academic program. These outcomes are typically broad and comprehensive, encompassing the knowledge, skills, attitudes, and behaviours that graduates should have acquired during their studies. Program Outcomes serve as benchmarks for assessing the overall effectiveness of the curriculum and educational experience. They often align with institutional goals, accreditation standards, and industry expectations. The Program Outcomes of FYUP in Physics are depicted in the Table 2

Table 2: Programme Specific Outcomes (PO) and Programme Specific Outcome (PO) Descriptor

PO	*Type of Programme Outcome (PO)*	*Programme Outcome (PO) Descriptor*
PO 1	Problem-Solving	A graduate student should be able to demonstrate the capability to: • solve problems of familiar and non-familiar contexts that are best approached with critical thinking and apply the learning to real-life situations.
PO 2	Analytical Reasoning & Critical Thinking	The graduates should be able to demonstrate the capability to: • apply analytical thought to a body of knowledge, including the analysis, evaluation and practices, as well as evidence, arguments, claims, beliefs, and the reliability and relevance of evidence, • identify relevant assumptions or implications; and formulate coherent arguments, • identify logical flaws in the arguments, • analyse and synthesise data from various sources, draw valid conclusions and support them with evidence and examples.
PO 3	Creativity (Innovation and creativity)	The graduates should be able to demonstrate the ability to: • create, perform, or think in different and diverse ways about the same objects or scenarios, • deal with problems and situations that do not have simple solutions, • innovate and perform tasks in a better manner, • view a problem or a situation from multiple perspectives, • think 'out of the box' and generate solutions to complex problems in unfamiliar contexts, • adopt innovative, imaginative, lateral thinking, interpersonal skills and emotional intelligence.
PO 4	Communication Skills	The graduates should be able to demonstrate the skills that enable them to: • listen carefully, read texts and research papers analytically, and present complex information clearly and concisely to peers and the public at large, • express thoughts and ideas effectively in writing and orally and communicate with others using appropriate media, • confidently share views and express herself/himself, • construct logical arguments using correct technical language related to a field of learning, work/vocation, or an area of professional practice, • convey ideas, thoughts, and arguments using respectful and sensitive language to gender and other minority groups.

PO 5	Research-related Skills	The graduates should be able to demonstrate: • a keen sense of observation, inquiry, and capability for asking relevant/ appropriate questions, • the ability to problematise, synthesize and articulate issues and design research proposals, • the ability to define problems, formulate appropriate and relevant research questions, formulate hypotheses, test hypotheses using quantitative and qualitative data, establish hypotheses, make inferences based on the analysis and interpretation of data, and predict cause-and-effect relationships, • the capacity to develop appropriate methodology and tools of data collection, • the appropriate use of statistical and other analytical tools and techniques, • the ability to plan, execute and report the results of an experiment or investigation, • the ability to understand basic research ethics and skills in practising/doing ethics in the field/ in personal research work, regardless of the funding authority or field of study.
PO 6	Coordinating / Collaborating with others	The graduates should be able to demonstrate the ability to: • work effectively and respectfully with diverse teams, • facilitate cooperative or coordinated effort on the part of a group, • act together as a group or a team in the interests of a common cause and work efficiently as a member of a team.
PO 7	Leadership Development	The graduates should be able to demonstrate the capability for: • mapping out the tasks of a team or an organization and setting direction. • formulating an inspiring vision and building a team that can help achieve the vision, motivating and inspiring team members to engage with that vision. • using management skills to guide people to the right destination.
PO 8	Digital and technological skills	The graduates should be able to demonstrate the capability to: • use ICT in a variety of learning and work situations, • access, evaluate, and use a variety of relevant information sources, • use appropriate software for analysis of data.

PO 9	Multicultural competence and inclusive spirit	The graduates should be able to demonstrate: • the acquisition of knowledge of the values and beliefs of multiple cultures and a global perspective to honour diversity, • capability to effectively engage in a multicultural group/society and interact respectfully with diverse groups, • capability to lead a diverse team to accomplish common group tasks and goals. • gender sensitivity and adopt gender-neutral approach, as also empathy to the less advantaged and the differently-abled including those with learning disabilities.
PO 10	Value inculcation	The graduates should be able to demonstrate the acquisition of knowledge and attitude that are required to: • embrace and practice constitutional, humanistic, ethical, and moral values in life, including universal human values of truth, righteous conduct, peace, love, nonviolence, scientific temper, citizenship values, • formulate a position/argument about an ethical issue from multiple perspectives • practice responsible global citizenship required for responding to contemporary global challenges, enabling learners to become aware of and understand global issues and to become active promoters of more peaceful, tolerant, inclusive, secure, and sustainable societies, • identify ethical issues related to work and follow ethical practices, including avoiding unethical behaviour such as fabrication, falsification or misrepresentation of data, or committing plagiarism, and adhering to intellectual property rights, • adopt objective, unbiased, and truthful actions in all aspects of work, • instil integrity, identify ethical issues related to work, and follow ethical practices.
PO 11	Environmental awareness and action	The graduates should be able to demonstrate the acquisition of and ability to apply the knowledge, skills, attitudes, and values required to take appropriate actions for: • recognize environmental and sustainability issues, and participate in actions to promote sustainable development. • mitigating the effects of environmental degradation, climate change, and pollution, • effective waste management, conservation of biological diversity, management of biological resources and biodiversity,
PO 12	Community engagement and service	The graduates should be able to demonstrate the capability to • participate in community-engaged services/ activities for promoting the well-being of society.

7.0 Programme Specific Outcomes of FYUP in Physics

The Programme Specific Outcomes (PSOs) are specific statements that describe the professional career accomplishments that the program is designed. The PSOs of the B.Sc. (Hons.) Physics/ B.Sc. (Hons.) Physics/ B.Sc. (Hons.) Physics with Research Programme in Physics division under University Institute of Sciences are as follows: The Programme Specific Outcomes (PSOs) are specific statements that describe the professional career accomplishments that the program is designed. The PSOs of the B.Sc. (Hons.) Physics/ B.Sc. (Hons.) Physics/ B.Sc. (Hons.) Physics with Research Programme in Physics division under University Institute of Sciences are as follows:

PSOs are statements that describe the specific knowledge, skills, and competencies that graduates of a Physics should possess. Programme Specific Outcomes are tailored to the unique focus and objectives of a specific specialization or concentration within the Bachelor of Science in Physics program. PSOs provide more detailed and targeted expectations for student learning outcomes within a particular discipline of Physics. They help to ensure that graduates are well-prepared for the specific demands and requirements of their chosen career paths or areas of specialization.

Table 3: Programme Specific Outcomes (PSO and Programme Specific Outcome (PSO) Descriptor

PSO	Type of Programme Specific Outcome (PSO)	Programme Specific Outcome (PSO) Descriptor
PSO 1	Knowledge & understanding	Graduates should be able to demonstrate the acquisition of: • basic understanding of various physics branches to develop a solid foundation for advanced-level courses and research work • principles of mathematics and their applications in physical theories as well as in experimental works • Integrate knowledge from various disciplines such as chemistry, mathematics, computer science to provide a holistic understanding of physical phenomena.
PSO 2	Application of Theory	• To enable students to effectively apply theoretical principles and mathematical frameworks of physics to solve real world problems. • Application of theoretical knowledge in designing and conducting experiments as well as to predict the outcome of the experiments. • Bridge the gap between theoretical physics and practical applications through hands-on experimentation.
PSO 3	Experimental Skills and Technical Competence	• Extensive hands-on experience with a variety of laboratory equipment to enhance technical competence. • Troubleshoot and solve technical issues that arise during experimental works

PSO 4	Computational Proficiency:	• proficiency in the use of computational tools for understanding mathematical theorems and physical phenomena. • To enhance skills in computer programming to simulate different phenomena and to solve complex physical problem.
PSO5	Advanced Knowledge and Applications	• Deep understanding of advanced topics quantum mechanics, statistical mechanics, condensed matter physics, particle physics and spectroscopy. • Knowledge on specialized areas such as astrophysics, solid state devices, low dimensional structures, Nanoscience, Nuclear structure and quantum systems. • theoretical proficiency by engaging with complex physical theories in mathematical frameworks.
PSO6	Personal Development and Lifelong Learning	• personal and professional growth through problem-solving, laboratory experiment, project work, scientific writing and presentations. • personal growth through critical thinking, problem-solving, and effective communication.

8.0 Program Learning Outcomes of FYUP in Physics

Program Learning Outcomes (PLOs) are specific, measurable statements that define what students are expected to know, be able to do, and value by the end of a degree program. They reflect the skills, knowledge, attitudes, and abilities that students will acquire through their educational experiences. Students graduating with a B.Sc. in Physics(Hons.) degree should be able to solid foundation in both the theoretical and practical aspects of physics as well as develop necessary skills and knowledge for a career in research, industry or further academic study. Here's a comprehensive outline of the Program Learning Outcomes (PLOs) for a typical FYUP in Physics:

PLO 1: Comprehensive Understanding in Physics:

- Acquire a fundamental/systematic and coherent understanding of the academic field of basic Physics in areas like Mechanics, Electricity and Magnetism, Waves and Optics, Thermal and Statistical Physics, Quantum Mechanics, Mathematical Physics and their applications to other core subjects in Physics.
- Attain a deep and integrated understanding of core physics concepts, principles, and theories, enabling them to analyze and synthesize knowledge across various domains of physics and apply this understanding to solve complex problems and pursue advanced study or professional practice.
- Learn to explore interdisciplinary topics through the knowledge of physics and their applications in fields such as biophysics, materials science, and environmental physics.

PLO 2: Interdisciplinary and Holistic Knowledge:

- Acquire knowledge of multiple disciplines and complementary fields to integrate them to get a holistic understanding of physical phenomena.
- Learn to use the principles and methodologies from different disciplines with physics to synthesize information from diverse sources as well as to develop innovative solutions for scientific, technological, and societal challenges.
- Learn to engage in multidisciplinary projects which broaden the scope of learning and application of Physics

PLO 3: Real-World Utilization of Theoretical Concepts

- Learn to Use mathematical formulations of physical theories to solve real-world problems in mechanics, electromagnetism, thermodynamics, and quantum mechanics and to pply analytical techniques to evaluate and interpret physical phenomena in practical settings.
- Develop skill to design experiments to test and apply theoretical models, adapting methodologies to real-world constraints and to analyse experimental data to verify theoretical predictions and draw meaningful conclusions for practical applications.
- Learn to Utilize contemporary physics software, tools, and instruments for practical applications such as simulations, modelling, and diagnostics and to apply physical principles in the development and optimization of new technologies.

PLO 4: Problem-Solving Skills

- Learn to identifying and applying appropriate physical phenomena to formulate and tackle physics-related problems.
- Grasp fundamental and advanced concepts in physics to identify the principles underlying physical problems and to Utilize logical reasoning to dissect problems and devise strategies for solving them.
- Learn to apply mathematical methods, including calculus, linear algebra, and differential equations, to model and solve physical problems.
- Use computational tools and programming languages to simulate physical systems and analyse data.
- Identify and clearly define physical problems from complex scenarios and to Critically evaluate solutions, considering their feasibility, accuracy, and broader implications.
- Learn to tackle open-ended problems that lie at the intersections of disciplinary boundaries by employing multidisciplinary strategies and integrating diverse methodologies.

PLO 5: Experimental Skills and Technical Competence (Experimental Proficiency)

- Acquire a wide-ranging and comprehensive experience in physics laboratory methods in experiments and gain the ability for systematic observations, use of scientific instruments with required safety and precautions.

- Plan and execute Physics-related experiments or investigations, analyze and interpret data/information collected using appropriate methods, including the use of appropriate software such as programming languages and packages.
- Learn to prepare data management and relating the investigations and findings of experiments to relevant theories of Physics.
- Develop troubleshooting skills to systematically diagnose, analyse, and resolve technical issues in experimental setups, ensuring accurate and reliable results by identifying root causes, implementing corrective actions, and optimizing experimental procedures.

PLO 6: Mathematical and Computational Proficiency:

- Recognize the importance of mathematical modelling, simulation and computational methods, and the role of approximation and mathematical approaches to describing the physical world and beyond.
- Acquire proficiency in the use of mathematical methods and computational tools to model and solve physical problems.
- Learn programming languages and software relevant to physics research and simulations.

PLO 7: Analytical Skill

- analytical skills involving paying attention to detail and the ability to construct logical arguments using correct technical language related to Physics and the ability to translate them with popular language when needed;
- Develop strong analytical skills to critically evaluate scientific data and research findings.

PLO 8: Innovation and Creativity:

- Foster creativity and innovation in approaching scientific problems and developing new experimental techniques.
- Encourage entrepreneurial thinking and the ability to translate scientific research into practical applications.

PLO 9: Advanced Knowledge and Applications:

- Gain information about contemporary topics of physics and learn to use this knowledge in analysing complex physical systems.
- Able to demonstrate a sophisticated understanding of advanced physics concepts and apply this knowledge to complex real-world problems, research, and emerging technologies.
- Learn to conduct new experiments and develop innovative solutions by integrating advanced physics concepts with technological and scientific advancements.

PLO 10: Research Skills:

- Graduates will develop robust research skills, enabling them to design and conduct scientific investigations, critically analyze data, and contribute original insights to the field of physics.
- Formulate research questions, hypotheses, and objectives for investigating physical phenomena as well as to design experiments with appropriate controls and variables to test hypotheses or explore new areas of physics.

- Conduct comprehensive literature reviews to identify gaps in existing knowledge and contextualize new research
- Critically analyze and synthesize existing research to inform and guide new investigations.
- Gain extensive hands-on experience in laboratory techniques and experimental methods.
- Conduct independent research projects, including designing experiments, collecting and analysing data, and interpreting results.
- Ability to perform independent research. Formulate hypotheses, design experiments or theoretical models, analyse data, and interpret results. Contribute to scientific knowledge through projects and publications.

PLO 11: Independent Investigation Skill:

- Conduct investigations autonomously, demonstrating self-direction and initiative in seeking out relevant information and resources.
- Adhere to ethical standards and guidelines in all stages of investigation, ensuring integrity, objectivity, and respect for confidentiality and participants' rights during independent investigation.

PLO 12: Scientific Communication:

- Develop effective communication skills to present complex scientific ideas and findings clearly and concisely written formats.
- Write detailed scientific reports and research papers, and participate in seminars and conferences.
- Effectively communicate complex scientific concepts and research findings to diverse audiences through clear and concise writing, oral presentations, and visual media. Collaborate with peers in interdisciplinary teams to achieve common research goals.

PLO 13: Presentation and Oral Communication

- Present information that is accurate, well-researched, and evidence-based, ensuring that data and findings are clearly explained and supported by relevant literature.
- Present complex information in a concise manner to different groups/audiences of technical or popular nature
- Skill to use appropriate scientific terminology in presentations and engage with the audience through effective communication techniques and responses to questions.

PLO 14: Ethical Responsibility:

- Understand the importance of ethical behaviour in the dissemination and application of scientific knowledge.
- Adhere moral practices in scientific research and experimentation to uphold a ethical research and professional practice.
- Uphold ethical standards in scientific practice, including honesty, integrity, and responsibility.

PLO 15: Information and Communication Technology (ICT) skills

- Demonstrate competency in using common software applications, such as word processing, spreadsheets, presentation tools, and databases, as well as basic internet skills.
- Efficiently locate, evaluate, and manage digital information, ensuring the accuracy and relevance of data for various tasks and projects.
- Utilize ICT tools to communicate and collaborate effectively, including email, video conferencing, and collaborative platforms.
- Understand and implement best practices for cybersecurity, data privacy, and ethical use of digital resources, ensuring the protection of information and compliance with legal standards.

PLO 16: Teaching and Mentoring

- demonstrate the ability to effectively teach and mentor students in physics, fostering a deep understanding of physical concepts and promoting scientific inquiry and critical thinking.
- Provide guidance and support to others in their academic and personal development, fostering a positive learning environment and encouraging scientific curiosity

PLO 17: Global and Societal Awareness

- Recognize the global impact of physics research and technological advancements. Contribute to discussions on environmental sustainability, energy solutions, and other societal issues through informed and responsible scientific practices.
- Recognize the societal implications of scientific advancements and contribute to informed public discourse on scientific issues.
- Understand the societal implications of scientific work and the importance of sustainable and ethical research practices.

PLO 18: Professional and Personal Development:

- Develop skills essential for professional growth, including project management, teamwork, and leadership.
- Foster personal growth through critical thinking, problem-solving, and effective communication.
- Cultivate a mindset for lifelong learning and continuous self-improvement.
- Stay updated with the latest developments in physics and related fields through active engagement in learning communities and professional societies.
- Demonstrate professional behaviour such as
    - (i) being objective, unbiased and truthful in all aspects of work and avoiding unethical, irrational behaviour such as fabricating, falsifying or misrepresenting data or committing plagiarism;
    - (ii) the ability to identify the potential ethical issues in work-related situations;
    - (iii) be committed to the free development of scientific knowledge and appreciate
    - (iv) its universal appeal for the entire humanity;
    - (v) appreciation of intellectual property, environmental and sustainability issues;
    - (vi) promoting safe learning and working environment.

PLO 19: Lifelong Learning and Adaptability

- Demonstrate the capacity for self-directed learning and adaptability in a rapidly evolving field. Stay informed about contemporary issues and advances in physics, and apply new knowledge and skills to various professional contexts.

PLO 20: Career and Graduate Preparedness

- Prepare for advanced studies or diverse career paths by developing a comprehensive skill set in physics. Achieve readiness for graduate programs or roles in industry, research, education, or technology sectors.
  (i) procedural knowledge that creates different types of professionals related to the disciplinary/subject area of Physics, including professionals engaged in research and development, teaching and government/public service.
  (ii) knowledge and skills in areas related to their specialization area corresponding to elective subjects within the disciplinary/subject area of Physics and current and emerging developments in the field of Physics.

9.0 Curricular components of the FYUP in Physics (Hons.)

The FYUP in Physics (Hons.) curriculum is designed to offer a robust and comprehensive educational experience. It features a core of major courses that delve deeply into theoretical as well as experimental physics, supplemented by minor courses that allow students to explore related disciplines. Multidisciplinary courses broaden students' perspectives by integrating knowledge from various fields, while language courses enhance their communication skills across different linguistic contexts. Skill-building courses focus on developing practical competencies crucial for scientific inquiry and professional success. Additionally, the curriculum includes specialized courses on Indian knowledge systems and environmental education, aiming to foster a holistic understanding of cultural heritage and ecological sustainability among aspiring physicists.

9.1 Major Courses:

These are the essential course of FYUP in Physics (Hons.) where students get a comprehensive platform to delve deeply into the diverse and intricate realms of physics. These courses are meticulously designed to provide a rigorous academic foundation and specialized knowledge essential for understanding fundamental principles, theories, and applications within the field. By exploring topics ranging from classical mechanics to quantum physics, students gain profound insights and analytical skills necessary for tackling complex scientific challenges. Through practical experiments, theoretical analyses, and collaborative projects, students not only enhance their academic prowess but also cultivate a deep-seated passion for advancing their understanding of the natural world through the lens of physics. The major courses in the FYUP Physics (Hons.) curriculum are divided into Core courses and Departmental Elective courses, offering students flexibility in their academic pursuits.

Core Courses: These Major Courses form the essential foundation of the program, covering fundamental concepts and required subjects necessary for all students pursuing the degree. These courses are designed to ensure a comprehensive understanding of key principles and theories within the field of study. This course includes Foundation or introductory course, Intermediate-level courses and Higher-level courses. The first year of the program requires students need to complete two foundation courses in order to acquire the basic information and skills required to begin their academic journey in physics. While in the 3rd, 4th, 5th, and 6th semesters, students have to go through several intermediate-level courses that serve as prerequisites for advanced-level major courses in the fourth year of their study. For achieving Honours in Physics within FYUP, Students need to enrol advanced-level core courses as Major in the 7th and 8th semester.

Departmental Elective Course: These elective courses provide students with the flexibility to tailor their academic journey according to their interests and career aspirations. These courses allow students to delve deeper into specialized areas of study or explore interdisciplinary topics that complement their major. Departmental Elective courses offer students the opportunity to customize their learning experience, fostering a more personalized and enriched educational path within the broader framework of the curriculum.

The criteria for selecting Departmental Elective Courses typically include relevance to the student's major and career goals, as well as meeting prerequisite requirements and considering faculty expertise and course availability. These factors ensure that students can tailor their academic journey effectively within the department's curriculum framework.

9.2 Minor Courses:

In this category, students must select a minimum of 4 credits per semester throughout the FYUP in Physics (Hons.) program, spanning from the 1st to the 8th semester, for their Minor courses. From the 1st to the 6th semester, students are required to enrol in Minor courses in either Chemistry or Mathematics. In the 7th and 8th semesters, they have the option to register for MOOC courses on the SWAYAM platform as per RGU guidelines. Students pursuing research after the 6th semester in FYUP in Physics (Hons.) must enrol in research-based courses as Minor courses in the 7th and 8th semesters. Alternatively, students without research can choose their Minor courses from either research-based courses or courses available on the SWAYAM platform.

9.3 Multidisciplinary Courses (09 credits):

Multidisciplinary courses refer to academic offerings that integrate knowledge and methodologies from multiple disciplines, providing students with a holistic understanding of complex topics from diverse perspectives. These courses aim to bridge traditional disciplinary boundaries, encouraging interdisciplinary collaboration and fostering a comprehensive approach to problem-solving and learning. Students of FYUP required to undergo three introductory level courses of new disciplines. Under this category, Students are not allowed to choose or repeat courses already undergone at the higher secondary level (12th class) in the proposed major and minor. Students have to be enrolled in such MDC courses in the 1st, 2nd, and 3rd semesters from the list of Multidisciplinary Courses provided by the Department of Rajiv Gandhi University/college conacred.

9.4 Ability Enhancement Courses (AEC):

To achieve competency in Languages and communication skills for the improvement of their intellectual minds, students have to enrol AEC courses on languages in the First and Second semester of FYUP as par the University regulations. There courses focus on developing students' proficiency in either language, depending on their academic needs and career aspirations. These courses aim to strengthen reading, writing, speaking, and comprehension skills in English or Hindi, enhancing students' ability to communicate effectively in professional and academic settings.

9.5 Skills Enhancement Courses (SEC):

These courses provide practical skills and competencies that are essential for students' during the study as well as their professional and personal growth. These courses focus on imparting specific skills such as critical thinking, problem-solving, teamwork, leadership, digital literacy, and communication skills. SECs are intended to prepare students to meet the challenges of the modern workplace by equipping them with the practical abilities and knowledge required to excel in their chosen careers. These courses often incorporate hands-on learning experiences simulations to enhance students' skill development and application. The prime objective of these courses is to enhance the employability of students. Students have to be enrolled in such Skill Enhancement Course of 3 credits each in the 1st, 2nd, and 3rd semester from the list of Skill Enhancement Courses. The credits earned in these courses enable students to exit from the programme after one year or two years of his/her study.

9.6 Value-Added Courses (VAC) (06 credits):

In FYUP of Rajiv Gandhi University, to promote holistic development by nurturing the physical, mental, social, and emotional well-being of students, three Value Added courses in the 1st, 2nd, and 3rd semesters of the programme. In the first year of the UG program, the two courses mandatory related to Environmental Studies are introduced under this category (VAC). These courses are EVS VA 0010: Environmental Science – I in the first semester and EVS VA 0020 Environmental Science –II in the second semester. These courses are mandatory for all students admitted to the FYUP programme of Rajiv Gandhi University. Whereas, in the third semester, students have the freedom to choose value added course offered by various departments of University or colleges as per the RGU regulations. However, students may also enrol in MOOCs from the SWAYAM platform, with a minimum of 2 credits, as value-added courses, subject to prior approval.

9.7 Summer Internship /Apprenticeship (General and mandatory) :

Each student enrolled in FYUP has to complete a a mandatory internship of 2 credits to feel the induction of actual work situations of India. He/she has the choice to undergo internships / Apprenticeships in a firm, industry, or organization or Training in labs with faculty and researchers in their own or other HEIs/research institutions during the summer term. Each Student will be provided with opportunities for internships with local industry, business organizations, health, and allied areas, local governments (such as panchayats, and municipalities), Parliament or elected representatives, media organizations, artists, crafts persons, and a wide variety of organizations so that students may actively engage with the practical side of their learning and, as a by-product, further improve their employability. A student has to follow the rules and regulations for this mandatory internship course provided by Rajiv Gandhi University.

9.8 Internship /Apprenticeship to exit from the courses:

The FYUP in Physics (Hons.) permits students to exit the programme before completing their full course of study, provided they meet the criteria stipulated by university regulations. The primary requirement to exit from the FYUP programme is completing an internship or apprenticeship worth 4 credits, which should be relevant to the skills acquired in skill-based courses during the first and second semesters. These Internship or apprenticeship programs serve as avenues for students to gain practical experience and apply theoretical knowledge in real-world settings, contributing significantly to their academic and professional development. These opportunities often provide hands-on training, industry insights, and networking opportunities, preparing students to transition successfully from their academic courses to professional careers.

9.9 Research Project / Dissertation:

Upon completing three years of study in the FYUP in Physics (Hons.), students are obligated to undertake a 12-credit research project supervised by a faculty member of the University/college. The students are expected to complete the Research Project in the eighth semester. The research outcomes of their project work may be published in peer-reviewed journals or may be presented in conferences /seminars or may be patented. From a selection of research project to award students has to follow the guidelines provide by the University.

9.10 Other Activities:

Students pursuing FYUP in Physics (Hons.) are have the choice to participate in various extracurricular activities that count towards their credit courses during their studies. This component will include participation in activities related to National Service Scheme (NCC), National Cadet Corps (NCC), adult education/literacy initiatives, mentoring school students, and other similar activities.

10.0 Course Structure:

The FYUP in Physics (Hons.) offers a structured course framework designed to provide students with a comprehensive understanding of fundamental and advanced concepts in physics. Beginning with foundational courses in mechanics, waves and oscillations, optics, thermal physics, electricity and magnetism students' progress through intermediate and advanced levels that include specialized topics. The curriculum integrates interdisciplinary and multidisciplinary courses enhancing students' analytical skills and broadening their scientific perspective. The practical components embedded in most of the major courses offer hands-on experience that enhances students' understanding and application of theoretical concepts. The program also culminates in projects allowing students to apply their knowledge under faculty guidance and preparing them for advanced academic or professional pursuits in physics.

Rajiv Gandhi University offers two variants of FYUP in Physics (Hons.): Four-Year Undergraduate Programme with Research and Four-Year Undergraduate Programme without Research. Students admitted to FYUP follow an identical course structure up to the 6th semester. After completing the 6th semester, the Department evaluates their performance and CGPA in accordance with RGU guidelines. Based on this evaluation, a limited number of students are selected for FYUP in Physics (Hons.) with Research, while others are enrolled in FYUP without Research. The detailed course structure for FYUP in Physics (Hons.) with Research is depicted in the Table 4 and the course structure for FYUP in Physics (Hons.) without Research is depicted in the Table 5.

Students in FYUP with Research and those in FYUP without Research pursue different courses during the 7th and 8th semesters as per the syllabus of their respective disciplines. In FYUP with Research students have to complete a Research Project of 12 Credit as per the university guidelines, whereas students enrolled in FYUP in Physics (Hons) without Research need to enrol three elective courses of 4 Credit each from the list of elective courses in Table 6 after discussing with the concerned mentor of the student. The Physics department of the University/college will offer these options to students based on the availability of faculty and laboratory facilities.

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Table 4: Course Structure of B.Sc. in Physics (Hons.) with Research

NCrF Level	Semester	Course Category	Course Code	Name of the Course	Credit	Semester Credit
4.5	**1st of FYUP**	Major 1	PHY-001-CC-1110	Mathematical Physics I	5	21
		Minor 1	XXX-001-MC-1110	Have to choose one course as per the university guidelines	4	
		MDC 1	XXX-001-MD-1110	Have to choose one course as per the university guidelines	3	
		AEC 1	XXX-001-AE-1110	Have to choose one course as per the university guidelines	4	
		SEC 1	PHY-001-SE-0010	Basics of Electronic Circuits	3	
		VAC 1	EVS-001-VA-1110	Environmental Science - I	2	
	2nd of FYUP	Major 2	PHY-001-CC-1210	Mechanics and Properties of Matter	5	21
		Minor 2	XXX-001-MC-1210	Have to choose one course as per the university guidelines	4	
		MDC 2	XXX-001-MD-1210	Have to choose one course as per the university guidelines	3	
		AEC 2	XXX-001-AE-1110	Have to choose one course as per the university guidelines	4	
		SEC 2	PHY-001-SE-0020	Electricity in Daily life	3	
		VAC 2	EVS- 001-VA-1210	Environmental Science - II	2	
Students exiting the programme after securing 42 credits will be awarded UG Certificate provided they secure 4 credits in work based vocational courses						
5.0	**3rd of FYUP**	Major 3	PHY- 001-CC-2110	Waves and Oscillations	5	22
		Major 4	PHY- 001-CC-2120	Optics	5	
		Minor 3	XXX-001-MC-2110	Have to choose one course as per the university guidelines	4	
		MDC 1	XXX-001-MD-2110	Have to choose one course as per the university guidelines	3	
		SEC 1	PHY-001-SE-0030	Fundamentals of Python	3	
		VAC 1	XXX-001-VA-2110	Have to choose one course as per the university guidelines (or **MOOC from SWAYAM**)	2	
	4th of FYUP	Major 5	PHY-001-CC-2210	Mathematical Physics II	5	22
		Major 6	PHY-001-CC-2220	Electricity and Magnetism	4	
		Major 7	PHY-001-CC-2230	Thermal Physics	4	
		Major 8	PHY-001-CC-2240	Electronics I	5	
		Minor 4	XXX-001-MC-2210	Have to choose one course as per the university guidelines	4	
Students exiting the programme after securing 86 credits will be awarded UG Diploma in Physics provided they secure 4 credits in work based vocational courses						

5.5	**5th of FYUP**	Major 9	PHY-001-CC-3110	Mathematical Physics - III	4	24
		Major 10	PHY-001-CC-3120	Classical Mechanics	4	
		Major 11	PHY-001-CC-3130	Quantum Mechanics	5	
		Major 16	PHY-001-CC-3140	Electronics II	5	
		Minor 5	XXX-001-MC-3110	Have to choose one course as per the university guidelines	4	
		Internship	PHY-001-IN-2210	Have to go through internship during the vacation period	2	
	6th of FYUP	Major 13	PHY-001-CC-3210	Statistical Mechanics	4	22
		Major 14	PHY-001-CC-3220	Atomic Physics	5	
		Major 15	PHY-001-CC-3230	Nuclear Physics	4	
		Major 12	PHY-001-CC-3240	Condensed Matter Physics	5	
		Minor 6	XXX-001-MC-3210	Have to choose one course as per the university guidelines	4	
Students who want to undertake 3-year UG programme will be awarded **UG Degree in Physics (B.Sc. in Physics)** upon securing 132 credits						
6.0	**7th of FYUP**	Major 17	PHY-001-CC-4110	Electrodynamics	4	22
		Major 18	PHY-001-CC-4120	Applications of Quantum Mechanics	4	
		Major 19	PHY-001-CC-4130	Solid State Devices	5	
		Minor 20	PHY-001-CC-4140	Numerical Methods in Physics	5	
		Minor 7	PHY-001-RC-4110	Research Methodology **(or MOOC on Research Methodology)**[1]	4	
	8th of FYUP	Major 21	PHY-001-CC-4210	Molecular Physics and spectroscopy	4	22
		Major 22	PHY-001-RP-4220	**Research Project**	12	
		Minor 8	PHY-001-RC-4210	Research and Publication Ethics **(or MOOC on Research Ethics)**[2]		
		VAC (Physics)	PHY-001-VA-4210	Indian Knowledge System: Concepts and Applications in Science **(or MOOC on IKS)**[3]	2	

[1] Instead of "PHY-001-RC-4110: Research Methodology" a student can opt a course form SWAYAM platform of 4 Credit and similar type with prior approval

[2] Instead of "PHY-001-RC-4210: Research and Publication Ethics" a student can opt a course form SWAYAM platform of 4 Credit and similar type with prior approval

[3] Instead of the Course "PHY-001-VA-4210: Indian Knowledge System: Concepts and Applications in Science" a student can opt a course form SWAYAM platform of 2 Credit and similar type with prior approval

Table 5: Course Structure of B.Sc. in Physics (Hons.) without Research

NCrF Level	Semester	Course Category	Course Code	Name of the Course	Credit	Semester Credit
4.5	**1st of FYUP**	Major 1	PHY-001-CC-1110	Mathematical Physics I	5	21
		Minor 1	XXX-001-MC-1110	Have to choose one course as per the university guidelines	4	
		MDC 1	XXX-001-MD-1110	Have to choose one course as per the university guidelines	3	
		AEC 1	XXX-001-AE-1110	Have to choose one course as per the university guidelines	4	
		SEC 1	PHY-001-SE-0010	Basics of Electronic Circuits	3	
		VAC 1	EVS-001-VA-1110	Environmental Science - I	2	
	2nd of FYUP	Major 2	PHY-001-CC-1210	Mechanics and Properties of Matter	5	21
		Minor 2	XXX-001-MC-1210	Have to choose one course as per the university guidelines	4	
		MDC 2	XXX-001-MD-1210	Have to choose one course as per the university guidelines	3	
		AEC 2	XXX-001-AE-1110	Have to choose one course as per the university guidelines	4	
		SEC 2	PHY-001-SE-0020	Electricity in Daily life	3	
		VAC 2	EVS- 001-VA-1210	Environmental Science - II	2	
Students exiting the programme after securing 42 credits will be awarded UG Certificate provided they secure 4 credits in work based vocational courses						
5.0	**3rd of FYUP**	Major 3	PHY- 001-CC-2110	Waves and Oscillations	5	22
		Major 4	PHY- 001-CC-2120	Optics	5	
		Minor 3	XXX-001-MC-2110	Have to choose one course as per the university guidelines	4	
		MDC 1	XXX-001-MD-2110	Have to choose one course as per the university guidelines	3	
		SEC 1	PHY-001-SE-0030	Fundamentals of Python	3	
		VAC 1	XXX-001-VA-2110	Have to choose one course as per the university guidelines (or **MOOC from SWAYAM**)	2	
	4th of FYUP	Major 5	PHY-001-CC-2210	Mathematical Physics II	5	22
		Major 6	PHY-001-CC-2220	Electricity and Magnetism	4	
		Major 7	PHY-001-CC-2230	Thermal Physics	4	
		Major 8	PHY-001-CC-2240	Electronics I	5	
		Minor 4	XXX-001-MC-2210	Have to choose one course as per the university guidelines	4	
Students exiting the programme after securing 86 credits will be awarded UG Diploma in Physics provided they secure 4 credits in work-based vocational courses						

5.5	**5th of FYUP**	Major 9	PHY-001-CC-3110	Mathematical Physics - III	4	24
		Major 10	PHY-001-CC-3120	Classical Mechanics	4	
		Major 11	PHY-001-CC-3130	Quantum Mechanics	5	
		Major 16	PHY-001-CC-3140	Electronics II	5	
		Minor 5	XXX-001-MC-3110	Have to choose one course as per the university guidelines	4	
		Internship	PHY-001-IN-2210	Have to go through internship during the vacation period	2	
	6th of FYUP	Major 13	PHY-001-CC-3210	Statistical Mechanics	4	22
		Major 14	PHY-001-CC-3220	Atomic Physics	5	
		Major 15	PHY-001-CC-3230	Nuclear Physics	4	
		Major 12	PHY-001-CC-3240	Condensed Matter Physics	5	
		Minor 6	XXX-001-MC-3210	Have to choose one course as per the university guidelines	4	
Students who want to undertake 3-year UG programme will be awarded **UG Degree in Physics (B.Sc. in Physics)** upon securing 130 credits						
6.0	**7th of FYUP**	Major 17	PHY-001-CC-4110	Electrodynamics	4	22
		Major 18	PHY-001-CC-4120	Applications of Quantum Mechanics	4	
		Major 19	PHY-001-CC-4130	Solid State Devices	5	
		Minor 20	PHY-001-CC-4140	Numerical Methods in Physics	5	
		Minor 7	PHY-001-RC-4110	Research Methodology (**or MOOC from SWAYAM**)[1]	4	
	8th of FYUP	Major 21	PHY-001-CC-4210	Molecular Physics and spectroscopy	4	22
		Major 22	PHY-001-DE-42XX0	Departmental Elective 1	4	
		Major 23	PHY-001-DE-42XX0	Departmental Elective 2	4	
		Major 24	PHY-001-DE-42XX0	Departmental Elective 3	4	
		Minor 8	PHY-001-RC-4210	Research and Publication Ethics (**or MOOC from SWAYAM**)[2]	4	
		VAC (Physics)	PHY-001-VA-4210	Indian Knowledge System: Concepts and Applications in Science (**or MOOC on IKS**)[3]	2	

[1,2] Instead of "PHY-001-RC-4110" and "PHY-001-RC-4210" a student can opt courses as a Minor form SWAYAM platform of equivalent credit with prior approval.

[3] Instead of the Course "PHY-001-VA-4210" a student can opt a course form SWAYAM platform of 2 Credit and similar type with prior approval

* Students have to choose three departmental electives in the eight semesters from the bucket of elective courses from Table 6 as per the guidelines

Table 6: Departmental Elective Courses for B.Sc. Physics (Hons.)

Sl. No.	Course Code	Name of the Course	Semester	Credit
1	PHY - 001 - DE - 42110	Advanced Mathematical Physics	Eight	4
2	PHY - 001 - DE - 42120	Nanomaterials and its Applications	Eight	4
3	PHY - 001 - DE - 42130	Basic Astronomy	Eight	4
4	PHY - 001 - DE - 42140	Basic Astrophysics	Eight	4
5	PHY - 001 - DE - 42150	Special Theory of Relativity	Eight	4
6	PHY - 001 - DE - 42160	Electronic Instrumentation	Eight	4
7	PHY - 001 - DE - 42170	Antenna and Wave Propagation	Eight	4
8	PHY - 001 - DE - 42180	Introduction to Arduino	Eight	4
9	PHY - 001 - DE - 42190	Introduction to Raspberry Pi	Eight	4
10	PHY - 001 - DE - 42200	Transport Properties of Materials	Eight	4
11	PHY - 001 - DE - 42210	Semiconductor technology and devices	Eight	4
12	PHY - 001 - DE - 42220	Electro-Optics and Opto-electronics	Eight	4
13	PHY - 001 - DE - 42230	Non-Equilibrium Statistical Mechanics	Eight	4
14	PHY - 001 - DE - 42240	Spin Dynamics and Magnetic Resonance	Eight	4
15	PHY - 001 - DE - 42250	Introduction to Quantum Computation	Eight	4
16	PHY - 001 - DE - 42260	Properties of Condensed Matter	Eight	4
17	PHY - 001 - DE - 42270	Physics of Thin Film	Eight	4
18	PHY - 001 - DE - 42280	Characterization of Materials	Eight	4
19	PHY - 001 - DE - 42290	Advanced Nuclear Physics	Eight	4
20	PHY - 001 - DE - 42290	Particle Physics	Eight	4

Table 7: Minor Courses from Physics

Sl. No.	Course Code	Name of the Course	Semester	Credit
1	PHY - 001 - MC - 4210	Mechanics and Properties of Matter	First	4
2	PHY - 001 - MC - 4220	Wave and Optics	Second	4
3	PHY - 001 - MC - 4230	Electricity and Magnetism	Third	4
4	PHY - 001 - MC - 4240	Thermal Physics	Fourth	4
5	PHY - 001 - MC - 4250	Modern Physics	Fifth	4
6	PHY - 001 - MC - 4260	Solid State Physics and Electronics	Sixth	4

Table 8: Multi-disciplinary Course (MDC)s from Physics

Sl. No.	Course Code	Name of the Course	Semester	Credit
1	PHY - 001 - MD - 4210	Physics for Everyone	First	3
2	PHY - 001 - MD - 4220	Electronics at a Glance	Second	3
3	PHY - 001 - MD - 4230	Knowing Our Universe	Third	3

MAJOR COURSES

Core Courses

PHY-001-CC-1110: MATHEMATICAL PHYSICS - I

NCrF Level:	4.5
Programme:	Four-Year Undergraduate Programme **Semester:** First
Course Category:	Major Course (Core Course)
Credit (L: T: P)	3: 0: 2
Credit Hours	Theory: 45 Hours, Practical: 60 Hours

1.0 COURSE LEARNING OBJECTIVES

The emphasis of course is to equip students with the mathematical and critical skills required in solving problems of interest to physicists. The Learning objectives of the courses are:

- Equip students with the ability to perform vector algebra, differentiate vector-valued functions, and evaluate vector integrals to solve complex problems in physics,
- Equip students with the ability to perform matrix operations, solve systems of linear equations, and apply matrix techniques to various applications
- Equip students with the skills to analyse and solve complex problems using curvilinear coordinates, including transformations and applications in various scientific contexts.
- Equip students with the ability to formulate, analyse, and solve ordinary and partial differential equations, applying them to model and interpret dynamic systems.
- Equip students with the ability to apply and analyse numerical methods for finding roots of equations and solving matrices.

2.0 COURSE LEARNING OUTCOME

After completing this course, students will be able to,

CO	Outcomes
CO1:	Draw and interpret graphs of various elementary functions and their combinations and use of Taylor's series for the drawing as well as evaluating elementary functions
CO2:	Understand the vector quantities as entities, their operation and their representation in terms of index notation to represent in compact form.
CO3:	Understand the concept of gradient of scalar field, divergence of vector fields and curl of vector field along with their physical significance.
CO4:	Understand the concept of vector integrals like line, surface, and volume integrals and theorem interrelating theses integrals and their applications.
CO5:	Gain a thorough understanding of matrix theory and its applications, preparing them for advanced studies and professional applications in fields that use linear algebra.
CO6:	able to understand, apply, and analyze the concepts and applications of curvilinear coordinate systems in solving complex physical and geometrical problems
CO7:	Learn various methods to solve ordinary differential equations and partial differential equations along with their applications in real-time physics problems.
CO8:	Learn to use of spreadsheet and open-source computer applications mathematical computations and data analysis through curve plotting in the laboratory.
CO9:	Learn numerical techniques to evaluate trigonometric functions and solve Algebraic and Transcendental equations in the laboratory.
CO10:	Able to prepare clear, structured, and concise scientific reports, effectively presenting laboratory works and findings with enhanced clarity.

3.0 SKILLS TO BE LEARNED

- To apply concepts of vectors for problem-solving in physics, engineering, and mathematics.
- To perform and use matrix operations in solving various problems of physics.
- To formulate, solve, and interpret differential equations for various practical problems.
- To use numerical methods for finding roots of equations and solving systems of linear equations.

4.0 DETAILED CONTENTS OF THE COURSE: THEORY

Credit: 3 **Classroom Teaching:** 45 Hours

MODULE 1

Functions: Elementary Functions and their representation through table, graph and equation, combination of functions, Symmetry of Functions, different types of elementary functions (linear, quadric, polynomial , algebraic, transcendental functions, trigonometric, exponential, hyperbolic functions, piecewise defined functions), inverse of a function, transformation of functions combinations of elementary functions, interpreting graphs of functions using the concepts of calculus, Taylor's series expansion for elementary functions. scalar function vs vector function, Multivariable functions. **[3 Hours]**

Vector Algebra: Transformation of Cartesian components of vectors under rotation of the axes, Index notation and summation convention, scalar and vector product and their physical significance, Product of vector of two, three and four vectors and representation in index notation using δ_{ij} and ε_{ijk} , Invariance of scalar product under rotation transformation. Scalar fields and vector fields. **[5 Hours]**

Vector Differentiation: Differentiation of a scalar and vector, Partial derivatives of functions with multiple variable - Product Rule, Quotient Rule, Power Rule, Chain Rule; Vector differential operator $\vec{\nabla}$, Gradient of a scalar field and its geometrical interpretation, normal and directional derivatives, Divergence and curl of a vector field and their physical significance. Del and Laplacian operators, Vector identities. **[7 Hours]**

MODULE 2

Vector Integration: Ordinary Integrals of Vectors, Multiple integrals: Jacobian. infinitesimal line, surface and volume elements. Line, surface and volume integrals of Vector fields. Flux of a vector field. Gauss' divergence theorem, Green's and Stokes Theorems and their applications (no rigorous proofs). **[5 Hours]**

Matrices: types of matrices, rank of a matrix, Addition, substation, Multiplication of matrix, Transpose of a Matrix. Symmetric and Skew-Symmetric Matrices. Conjugate of a Matrix. Hermitian and Skew-Hermitian Matrices. Singular and Non-Singular matrices. Orthogonal and Unitary Matrix. Trace of a Matrix. Inner Product. Inverse of a matrix, Eigen-values and Eigenvectors, Cayley- Hamilton Theorem. **[5 Hours]**

Orthogonal Curvilinear Coordinates: Orthogonal Curvilinear Coordinates, Line, surface and volume element in Spherical and Cylindrical Coordinate Systems, Derivation of Gradient, Divergence, Curl and Laplacian in Cartesian, Spherical and Cylindrical Coordinate Systems. **[5 Hours]**

MODULE 3

Ordinary Differential Equations: Formation of differential equation, **First** order differential equations of degree one and those reducible to this form, Exact and Inexact equations, Integrating Factor, Applications to physics problems. Higher order linear homogeneous differential equations with constant coefficients, Wronskian and linearly independent functions. Non-homogeneous second order linear differential equations with constant coefficients, complementary function, particular integral and general solution, Determination of particular integral using method of undetermined coefficients and method of variation of parameters, Cauchy-Euler equation, Initial value problems. Applications to physics problems. **[12 Hours]**

Partial Differential Equations: Solutions to partial differential equations, using separation of variables: Laplace's Equation in problems of rectangular, cylindrical and spherical symmetry **[3 Hours]**

5.0 DETAILED CONTENTS OF THE COURSE: PRACTICUM

Credit: 2 **Laboratory Work:** 60 Hours

In the practicum component of the course, students will undergo hands-on experience with precise plotting of mathematical curves manually on graph paper and digitally using spreadsheet applications in a computer. Through a series of practical exercises, students will learn to draw various curves, analyse their properties, and understand their applications. It emphasises the importance of accuracy in graphical representation to visualize and interpret physical phenomena. Moreover, students have learned and to through some manual exercises on numerical computation and spreadsheet applications. Students must compile comprehensive reports on each laboratory exercise performed.

The teacher has the flexibility to introduce additional exercises that directly correlate with and reinforce the topic discussed in the laboratory class.

Data Analysis using graphical plot in graph paper

a) To Draw the curve of the functions - linear, quadric, polynomial, algebraic, transcendental functions, trigonometric, exponential, hyperbolic functions in graph paper
b) To plot the approximate value of logarithmic, exponential and trigonometric functions calculated using Taylor's series to higher order and error estimation
c) To calculate mean values, standard deviations, and percentage errors for a set of data and to evaluate the accuracy and precession of the data
d) To study the physical significance of integration and differentiation of different functions using graphical method.
e) To fit a curve for a specific data set using different methods.

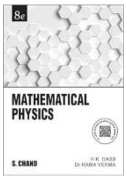
Data Analysis using Computer Applications:

a) To draw and analysis of curves in spreadsheet applications.
b) To use Open-source applications (Scilab, Python, Octave) for mathematical compilation
c) To use of open-source applications to plot a function or a experimental dataset.

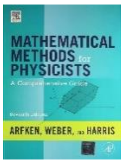
Numerical Computation

a) To solve Algebraic and Transcendental equation graphically and numerical techniques using Bisection, Newton Raphson and Secant methods though calculator/spreadsheet applications.
b) To Solve the system of quadratic equation,: $\alpha = \tan\alpha$, $I = I_0 \left[\frac{\sin\theta}{\alpha}\right]^2$
c) Interpolation by Newton Gregory Forward and Backward difference formula, error estimation.
d) Evaluation of trigonometric functions e.g. - $\sin\theta$, $\cos\theta$, $\tan\theta$ etc.
e) Determine the inverse of and matrices using cofactor method
f) To solve a linear system of four/five different equations using the matrix inverse method.
g) To Solve linear systems of four/five different equations using Gauss elimination method.
h) To Solve a system of four/five different equations using the Gauss-Jordan elimination method.
i) To Solve a system of four/five different equations using the LU-decomposition method.
j) Solving linear systems of equations, Matrix factorizations, eigen value and eigen function.
k) Exercise on Curve fitting, least square fit, Goodness of fit, standard deviation:

6.0 TEXT BOOKS

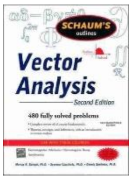


Name: Mathematical Physics
Author: H.K. Dass and R. Verma
Edition:8th Ed. (2022)
Publisher: S. Chand & Company.
ISBN: 978-9352837229

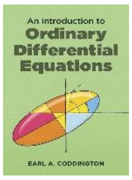


Name: Mathematical Methods for Physicists,
Author: G.B. Arfken, H.J. Weber, F.E. Harris
Edition: 7th Edn
Publisher: Elsevier
ISBN: 978-9381269558

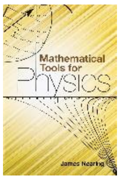
7.0 REFERENCE BOOKS AND MATERIALS



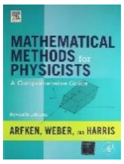
Name: Schaum's Outline of Vector Analysis
Author: Spiegel Murray
Edition: 2nd Ed (2009).
Publisher: McGraw-Hill Education, India
ISBN: 978-0071615457



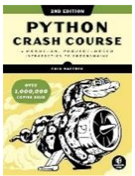
Name: An introduction to ordinary differential equations,
Author: E.A. Coddington
Edition: 2009
Publisher: PHI learning.
ISBN:



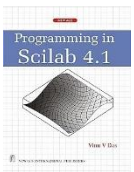
Name: Mathematical Tools for Physics
Author: James Nearing
Edition: 2010
Publisher: PHI learning.
ISBN:



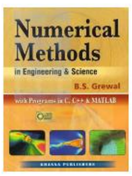
Name: Mathematical Methods for Physicists,
Author: G.B. Arfken, H.J. Weber, F.E. Harris
Edition: 7th Edn
Publisher: Elsevier
ISBN:



Name: Python Crash Course
Author: Eric Matthes
Edition: 2nd Ed (2019)
Publisher: No Starch Press
ISBN: 9781718502703



Name: Mathematical Tools for Physics
Author: Vinu V. Das
Edition: 2008
Publisher: New Age International Publisher
ISBN: 978-8122424713



Name: Numerical Methods in Engineering & Science
Author: B. S. Grewal
Edition: 10th Ed.
Publisher: Khanna Publishers
ISBN: 9788174092489

8.0 MAPPING OF CLO TO PO AND PSO

The course outcomes and their mapping with program outcomes are specified in the table below

Course Learning Outcomes	Programme Outcomes (POs)												Programme Specific Outcome (PSOs)					
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6
CO1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

9.0 ASSESSMENT SCHEME

The evaluation system for this course consists of an 80% weightage on a comprehensive theory examination, which assesses students' understanding of various course topics, and a 20% weightage allocated to internal assessments, including internal examinations, assignments, class participation, and overall engagement in the course throughout the semester.

THEORY:

(A) Internal assessment: (20 marks): Continuous evaluation and internal assessment are implemented to foster and maintain a thorough understanding throughout the learning process. By regularly assessing comprehension through assignments, quizzes, and class participation, educators can address learning gaps promptly and support students in achieving deeper knowledge and proficiency in the subject matter.

(B) End-term examination (80 marks): The end-term examination serves as a culmination of students' learning in the course, assessing their comprehensive understanding and proficiency in various topics in the course. It provides a structured platform for students to demonstrate their knowledge, problem-solving abilities, and application of theoretical concepts, ultimately gauging their readiness to progress. Pattern of End term question paper

Section	Total Questions	Marks for each question	have to attempt	Total Marks
A	5	4	4	20
B	5	10	3	30
C	4	15	2	30

PRACTICUM:

(A) Internal assessment: (20 marks): In the internal assessment of the practicum components, the student's performance, understanding, skills, sincerity, and involvement in laboratory work during the entire semester are evaluated.

(B) End-term examination (80 marks): The ability to apply theoretical knowledge to real-world situations is the fundamental criterion used in the End Term examination. It typically involves students' activity on randomly assigned laboratory works and the Laboratory Report (Notebook) on the performed work in the entire semester. In the End examination, the student must complete randomly assigned tasks and prepare a report on their work, including appropriate conclusions. The mark distribution for the End term examination as follows.

Activity	Marks
Laboratory work in the Examination	40
Laboratory Notebook	20
Presentation/Viva-voce	20

PHY-001-CC-1210: MECHANICS AND PROPERTIES OF MATTER

NCrF Level:	4.5	
Programme:	Four Year Undergraduate Programme	**Semester:** Second
Course Category:	Major Course	
Credit (L: T: P)	3: 0: 2	
Credit Hours	Theory: 45 Hours, Practical 60 Hours	

1.0 COURSE LEARNING OBJECTIVES

The course is to develop a comprehensive understanding of the fundamental principles of mechanics as well as basic properties of matter like elasticity, viscosity and surface tension. Additionally, the course aims to enhance critical thinking, and problem-solving skills, and to apply these principles to practical and real-world problems. The Learning Objectives of the Course are:

- Understand and articulate core principles of mechanics, including Newton's laws of motion, energy conservation, and the dynamics of particles and rigid bodies.
- Apply principles of mechanics to analyze and solve complex problems involving forces, motion, energy, and momentum in various mechanical systems.
- Evaluate the mechanical behaviour of systems, including translational and rotational motion, using principles of kinematics and dynamics.
- Equip students with the understanding and ability to analyze elasticity, viscosity, and surface tension in various materials, and apply these principles to solve practical engineering and scientific problems.

2.0 COURSE LEARNING OUTCOME

After completing this course, students will be able to,

CO	Outcomes
CO1:	Understand the fundamentals of dynamics along with the concept of the reference frame and to solve real world physical problems
CO2:	the phenomena of collisions and ideas about center of mass and laboratory frames and their correlation.
CO3:	Understand the analogy between translational and rotational dynamics along with the of moment of inertia as well as to calculate moment of inertia for different mass distributions
CO4:	Understand about the Gravitation in the universe and Kepler's law to describe the motion of planets and satellites in circular orbit along with their applications
CO5:	Understand the theory behind material deformation under stress, the concept of concepts of elastic constants and its applications.
CO6:	Learn the principal of flow fluid and viscosity including governing laws and theorems and its applications in actual circumstances.
CO7:	Understand about the forces at the surface of liquids, concept of surface tension and its effect in day-to-day applications.
CO8:	Skill in using different measuring instruments in the laboratory with necessary precautions and their applications to study the laws of mechanics and properties of matters.
CO9:	Able to prepare clear, structured, and concise scientific reports, effectively presenting laboratory works and findings with enhanced clarity.

3.0 SKILLS TO BE LEARNED

- To solve problems related to linear and rotational motion
- To solve practical problems related to elasticity, viscosity and surface tension. n
- Use of various types of measuring instruments used in Physics Laboratories.
- Art of scientific report wringing of laboratory work.

4.0 DETAILED CONTENTS OF THE COURSE: THEORY

Credit: 3 **Classroom Teaching: 45 Hours**

MODULE 1

Fundamentals of Dynamics: Inertial and Non-inertial frames- fictitious forces, Newton's Laws of Motion and their invariance under Galilean transformations. Momentum of variable mass system: motion of rocket, Motion of a projectile in Uniform gravitational field. Dynamics of a system of particles: principle of conservation of momentum. Impulse. Determination of centre of mass of discrete and continuous objects having cylindrical and spherical symmetry, Differential Analysis of a static vertically hanging massive rope **[7 Hours]**

Work and Energy: Work and Kinetic Energy Theorem. Conservative forces and examples (Gravitational and electrostatic), non-conservative forces and examples (velocity dependent forces e.g., frictional force, magnetic force). Potential Energy. Energy diagram. Stable, unstable and neutral equilibrium. Elastic potential energy, Force as gradient of the potential energy. Work & Potential energy, Work done by non-conservative forces. Law of conservation of Energy **[5 Hours]**

Collisions: Elastic and inelastic collisions, Kinematics of 2 → 2 scattering in centre of mass and laboratory frames. **[3 Hours]**

MODULE 2

Rotational Dynamics: Angular momentum of a particle and system of particles. Torque. Principle of conservation of angular momentum. Rotation about a fixed axis. Determination of moment of inertia of symmetric rigid bodies (rectangular, cylindrical and spherical). Application of parallel and perpendicular axes theorems. Kinetic energy of rotation. Motion involving both translation and rotation**,** Rotating frame of references, Centrifugal force, Coriolis force and its applications. **[8 Hours]**

Central Force Motion: Central forces, Law of conservation of angular momentum for central forces, Two-body problem and its reduction to equivalent one-body problem and its solution. Concept of effective potential energy and stability of orbits for central potentials of the form kT^n for $n = 2$ and -1 using energy diagram, discussion on trajectories for $n = -2$. Solution of Kepler's problem, Kepler's laws for planetary motion, orbit for artificial satellites. **[7 Hours]**

MODULE 3

Elasticity: Relation between the three elastic constants, Poison's ratio, Twisting torque on a Wire, Determination of Rigidity modulus by static torsion, Torsional pendulum, Determination of Rigidity modulus and moment of inertia - q, η and γ by Searles method. Bending of beam, bending moment, cantilever, depression of a beam supported at the ends and loaded at the centre, determination of Young's modulus by banding of beam. **(7 Lectures)**

Viscosity: Streamline flow, Turbulent flow, critical velocity, Reynolds Number and its significate, Bernoulli's Theorem, Poiseuille's equation, determination of coefficient of viscosity by Poiseuille's method. - Variations of viscosity of liquid with temperature- lubrication **(4 Lectures)**

Surface Tension: Pressure difference across a curved surface, expression for excess pressure inside a spherical drop and spherical shop bubble, Jaeger's method and Ferguson method. **(4 Lectures)**

5.0 DETAILED CONTENTS OF THE COURSE: PRACTICUM

Credit: 2 **Laboratory Work: 60 Hours**

In the practicum component of the course, students will undergo a number of experiments related to motion of object and properties of materials. During the experiment students will undergo precise measurement of physical parameter and analysis of the measured data to determine different physical quantities. Initially students have to familiarize themselves with the use of different measuring instruments as mentioned in the section (A). Here are some of the key measuring instruments

Students are required to conduct experiments from the provided list, meticulously following the suggested procedures and protocols outlined for each. Subsequently, they must compile comprehensive reports for every experiment, adhering to scientific standards and conventions. These reports should encompass a detailed description of the experimental setup and methodology employed, including any modifications made during the course of the experiment. Furthermore, students are expected to record and analyze their experimental data systematically, drawing upon relevant theoretical concepts and principles to interpret their findings accurately. Additionally, the reports should include a thorough discussion of the results obtained, highlighting any observed trends, anomalies, or correlations, and offering insightful explanations or hypotheses where applicable. Moreover, students must demonstrate proficiency in presenting their results graphically, utilizing tables, figures, and diagrams to enhance clarity and facilitate comprehension. Finally, each report should conclude with a succinct summary of the key findings and conclusions drawn from the experiment, along with any recommendations for further investigation or improvement.

The teacher has the flexibility to introduce a wide range of laboratory experiments that directly correlate with and reinforce the theoretical concepts covered in the course curriculum. These experiments serve as practical applications of the theoretical principles discussed in lectures.

Laboratory activity and skills:

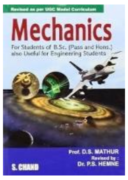
(a) Use of Vernier Calipers to measure (i) diameter of a small spherical/cylindrical body (ii) the internal diameter and depth of a given cylindrical object like beaker.
(b) Use of screw gauge to measure (i) diameter of a given wire and (ii) thickness of a given sheet
(c) To use of a Sextant to measurement the height of a building
(d) Use of travelling microscope for the accurate measurement of small gap between to objects
(a) Use of spherometer to determine the radius of curvature of a given spherical surface
(b) Methods for precise measurement using measuring Tape, sprit level, stopwatch, Spring Balance and laboratory balance.
(c) To study the random error in observations.

List of experiments:

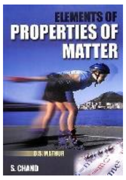
1) Measurement of the weight of a given body (a wooden block) using the parallelogram law of vector addition.
2) To study the relation between force of limiting friction and normal reaction and to find the coefficient of friction between surface of a moving block and that of a horizontal surface.
3) To find the downward force, along an inclined plane, acting on a roller due to gravity and study its relationship with the angle of inclination by plotting graph between force and $\sin\theta$
4) Using a Simple Pendulum plot $L-T$ and $L-T^2$ graphs, hence find the effective length of second's pendulum using appropriate graph
5) To determine g and velocity for a freely falling body using Digital Timing Technique.
6) To determine the Moment of Inertia of a Flywheel about its own axis of rotation
7) To determine the value of acceleration due to gravity(g) with the help of a Bar Pendulum.

8) To determine the value of acceleration due to gravity (g) with the help of a Kater's Pendulum
9) To determine the moment of inertia of a given body by means of inertia table and the help of an auxiliary body whose moment of inertia can be calculated from its dimensions.
10) To determine Young's modulus of the material of a given wire by using Searle's apparatus
11) To determine the Young's Modulus of a Wire by Optical Lever Method
12) To determine the Modulus of Rigidity of a Wire by Maxwell's needle.
13) Determination of Young's Modulus(Y), Rigidity Modulus(η) and Poisson ratio (σ) of a wire by Searle's method.
14) Determination of Young's Modulus of the material of a beam by the Koeing's method (method of bending)
15) To verify Stokes' law and hence to determine the coefficient of viscosity of a liquid.
16) Determination of the coefficient of viscosity of liquid by its flow through a capillary tube (Poiseuille's method)
17) To determine Coefficient of Viscosity of water by Capillary Flow Method (Poiseuille's method).
18) To determine the surface tension of water by capillary rise method and verification of Jurin's Law.
19) Determination of Surface Tension of a liquid-by-liquid drop method.
20) Determination of surface tension of liquid with temperature by Jaegar's method.

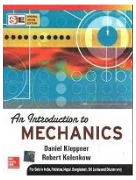
6.0 TEXT BOOKS



Name: Mechanics
Author: D.S. Mathur
Edition: 2000
Publisher: S. Chand & Company Ltd.
ISBN: 978-8121905992



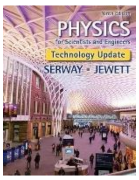
Name: Properties of Matter
Author: D.S. Mathur
Edition: 2010
Publisher: S. Chand & Company Ltd.
ISBN: 978-8121908153



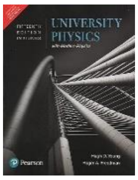
Name: Properties of Matter
Author: D. Kleppner, R.J. Kolenkow
Edition: 2017
Publisher: McGraw Hill Education
ISBN: 978-0070647787

7.0 REFERENCE BOOKS AND MATERIALS

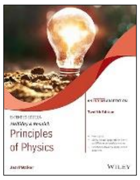
Name: Mechanics, Berkeley Physics, vol.1
Author: C.Kittel, W.Knight
Edition: 2nd Ed.
Publisher: McGraw-Hill Education, India
ISBN: 978-0070702134



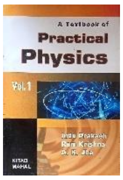
Name: Physics for scientists and Engineers with Modern Physics
Author: J.W. Jewett, R.A. Serway,
Edition: 9th Ed.
Publisher: Brooks/Cole
ISBN: 978-1305116399



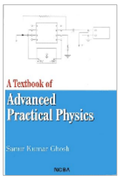
Name: University Physics
Author: Ronald Lane Reese
Edition: 7th Edn
Publisher: Pearson Education
ISBN: 978-9353949297



Name: University Physics
Author: Ronald Lane Reese
Edition: 20th Ed.
Publisher: Wiley India Private Limited
ISBN: 978-9357460835



Name: A textbook of Practial Physics
Author: Indu Prakash, Rama Krishna, A.K. Jha
Edition: 2011
Publisher: Kitab Mahal
ISBN: 978-8122504163



Name: A Textbook of Advanced Practical Physics
Author: Samir Kumar Ghosh
Edition: 2008
Publisher: New Central Book Agency
ISBN: 978-8173812439

6.0 MAPPING OF CLO TO PO AND PSO

The course outcomes and their mapping with program outcomes are specified in the table below

Course Learning Outcomes	Programme Outcomes (POs)												Programme Specific Outcome (PSOs)					
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6
CO1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

9.0 ASSESSMENT SCHEME

The evaluation system for this course consists of an 80% weightage on a comprehensive theory examination, which assesses students' understanding of various course topics, and a 20% weightage allocated to internal assessments, including internal examinations, assignments, class participation, and overall engagement in the course throughout the semester.

THEORY:

(A) Internal assessment: (20 marks): Continuous evaluation and internal assessment are implemented to foster and maintain a thorough understanding throughout the learning process. By regularly assessing comprehension through assignments, quizzes, and class participation, educators can address learning gaps promptly and support students in achieving deeper knowledge and proficiency in the subject matter.

(B) End-term examination (80 marks): The end-term examination serves as a culmination of students' learning in the course, assessing their comprehensive understanding and proficiency in various topics in the course. It provides a structured platform for students to demonstrate their knowledge, problem-solving abilities, and application of theoretical concepts, ultimately gauging their readiness to progress. Pattern of End term question paper

Section	Total Questions	Marks for each question	have to attempt	Total Marks
A	5	4	4	20
B	5	10	3	30
C	4	15	2	30

PRACTICUM:

(A) Internal assessment: (20 marks): In the internal assessment of the practicum components, the student's performance, understanding, skills, sincerity, and involvement in laboratory work during the entire semester are evaluated.

(B) End-term examination (80 marks): The ability to apply theoretical knowledge to real-world situations is the fundamental criterion used in the End Term examination. It typically involves students' activity on randomly assigned laboratory works and the Laboratory Report (Notebook) on the performed work in the entire semester. In the End examination, the student must complete randomly assigned tasks and prepare a report on their work, including appropriate conclusions. The mark distribution for the End term examination as follows.

Activity	Marks
Laboratory work in the Examination	40
Laboratory Notebook	20
Presentation/Viva-voce	20

PHY-001-CC-2110: WAVES AND OSCILLATIONS

NCrF Level:	5.0	
Programme:	Four-Year Undergraduate Programme	**Semester:** Third
Course Category:	Major Course	
Credit (L: T: P)	3: 0: 2	
Credit Hours	Theory: 45 Hours, Practical: 60 Hours	

1.0 COURSE LEARNING OBJECTIVES

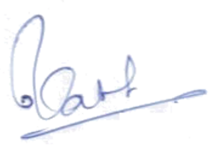
This course reviews the concepts of oscillation and waves learnt at school from a more advanced perspective and goes on to build new concepts. The Learning Objective of the Course are:

- Understand and analyse oscillatory motion, including simple harmonic motion and its applications in mechanical systems.
- Describe wave phenomena such as interference, diffraction, and standing waves, and apply wave equations to solve related problems.
- Explore the propagation of sound waves, including factors affecting intensity, frequency, and Doppler shift.
- Apply principles of oscillations, wave mechanics, and sound propagation to analyse practical scenarios in acoustics, communication, and engineering.

2.0 COURSE LEARNING OUTCOME

After completing this course, students will be able to,

CO	Outcomes
CO1:	Learn the characteristics of harmonic oscillations and dynamics of pendulum and muss-spring systems along with superposition of such oscillation in different circumstances.
CO2:	Learn the behaviour of oscillatory systems under the influence of damping forces and the response of the system along with its applications in real world.
CO3:	Learn to analyse systems subjected to external periodic driving forces, understand resonance phenomena, and apply these concepts to real-world engineering and physics problems.
CO4:	Able to analyse the behaviour of systems with multiple coupled oscillators, identify normal modes and frequencies, and apply these principles to practical problems in various fields.
CO5:	Learn the fundamental principles governing wave propagation, analyse wave behaviour in various media, and to apply wave concepts to real-world phenomena in physics.
CO6:	Understand the principle of superposition of waves, formation of standing waves and to analysis such waves different systems like string, pipe, bar etc.
CO7:	Learn fundamental properties of sound waves and their manifestation in various environments along with the knowledge to apply this in practical scenario.
CO8:	Understand the principles governing sound production in musical instruments, enabling them to analyse and differentiate between various instrument families
CO9:	Acquire practical skills in conducting experiments related to wave propagation using different laboratory equipment and to reinforce the theoretical concept learned in lectures.
CO10:	Able to prepare clear, structured, and concise scientific reports, effectively presenting laboratory works and findings with enhanced clarity.



3.0 SKILLS TO BE LEARNED

- To analyse oscillatory phenomena, including simple harmonic motion, damping, and resonance.
- to analyse wave properties such as frequency, wavelength, amplitude
- To analysis propagation of sound waves and their characteristics as well as Doppler effect.,
- To explain and analyse acoustics and behaviour of musical instruments.

DETAILED CONTENTS OF THE COURSE

Credit: 3 **Classroom Teaching: 45 Hours**

MODULE 1

Simple Harmonic Motion: Differential equation of simple harmonic oscillator, its solution and characteristics, energy in simple harmonic motion, linearity and superposition principle, rotating vector representation of simple harmonic oscillation, motion of simple and compound pendulum (Bar and Kater's pendulum), loaded spring. **[5 hours]**

Superposition of Harmonic Oscillations: Superposition of N collinear harmonic oscillations with (1) equal phase differences and (2) equal frequency differences, Beats. Superposition of two perpendicular harmonic oscillations (1) equal frequencies (2) slightly different frequencies, Graphical and Analytical Methods. Lissajous Figures, effect of variation of phase, applications of Lissajous figures. Equivalence of Uniform circular motion and mutually perpendicular harmonic oscillators. **[4 hours]**

Damped Oscillations: Undamped and Damped Oscillations - Equation of motion, solution of equation of motion of 1-D Damped Oscillators, deadbeat motion, critically damped system, lightly damped system: relaxation time, logarithmic decrement, quality factor **[6 hours]**

MODULE 2

Forced Oscillations: Equation of motion, complete solution, steady state solution - Forced Oscillations of a 1D weakly (lightly) damped force oscillator, amplitude and velocity resonance, power dissipation, sharpness of resonance, quality factor, **[4 hours]**

Coupled Oscillations: Coupled oscillators (longitudinal and transverse), small oscillation approximation, coupled simple pendulums - normal coordinates and normal modes, energy relation and energy transfer in coupled masses and coupled pendulum, di-atomic molecules, representation of a general solution as a linear sum of normal modes, normal modes of N coupled oscillators. **[7 hours]**

Wave Motion: Wave formation and propagation - Transverse and longitudinal, plane wave, classical wave equation, phase velocity. Energy transported by progressive wave, Intensity of wave, traveling wave solution, Waves in a string and membrane. Longitudinal wave in solids and gasses, velocity of a longitudinal wave. **[4 hours]**

MODULE 3

Superposition of Waves: Stationary Waves, phase velocity and group velocity, Waves in a String in membranes, normal modes in stretched strings, plucked string, struck string, bowed string, transverse vibration in membranes, Melde's Experiment. Waves in air columns - Normal Modes. Open and Closed Pipes, Longitudinal and Transverse vibrations of a Bar, Tuning Fork. **[6 hours]**

Sound waves: Characteristics- frequency, pitch, and amplitude, Link between frequency and pitch, Link between amplitude and loudness – decibels and phon, Speed of sound,, Newton's Formula and Laplace's Correction. Doppler effect, Acoustics - Reverberation and time of reverberation, Sabine's Law. Sonar and ultrasound technology, Sound Perception- human ear, Limits of Audibility **[6 hours]**

Musical Sound and Noise: characteristics of musical sound, Intensity and loudness of music, musical notes and musical scale – cord, harmony, overtone. Tuning systems and temperament, Melody, Noise and its characterizes – noise parameters, frequency analysis of noise. [**3 hours]**

5.0 DETAILED CONTENTS OF THE COURSE: PRACTICUM

Credit: 2 **Laboratory Work: 60 Hours**

In the practicum component of the course, students will undergo hands-on experience with the principles of oscillations, waves, and sound. Initially, students are familiar with the use of signal generators, Cathode Ray Oscilloscope and digital storage oscilloscope for further experiments. To understand the fundamental concepts students, have to go through a number of laboratory activities related to waves and oscillations. Finally, experiments are conducted to illustrate fundamental principles, measure physical quantities, and analyse data to understand wave phenomena.

Students are required to conduct experiments from the provided list, meticulously following the suggested procedures and protocols outlined for each. Subsequently, they must compile comprehensive reports for every experiment, adhering to scientific standards and conventions. These reports should encompass a detailed description of the experimental setup and methodology employed, including any modifications made during the course of the experiment. Furthermore, students are expected to record and analyze their experimental data systematically, drawing upon relevant theoretical concepts and principles to interpret their findings accurately. Additionally, the reports should include a thorough discussion of the results obtained, highlighting any observed trends, anomalies, or correlations, and offering insightful explanations or hypotheses where applicable. Moreover, students must demonstrate proficiency in presenting their results graphically, utilizing tables, figures, and diagrams to enhance clarity and facilitate comprehension. Finally, each report should conclude with a succinct summary of the key findings and conclusions drawn from the experiment, along with any recommendations for further investigation or improvement.

The teacher has the flexibility to introduce a wide range of laboratory experiments that directly correlate with and reinforce the theoretical concepts covered in the course curriculum. These experiments serve as practical applications of the theoretical principles discussed in lectures.

Experimental Skill:

(a) Analyze the waveform, frequency, amplitude, and phase of and signal generated by a signal generator.
(b) Understand the relationship between two perpendicular harmonic oscillations using Lissajous Figures.
(c) Demonstrate and analyze sound waves produced by different sources (vibrating systems)
(d) Understand the frequency, wavelength, intensity, pitch, loudness, sound pressure, harmonics and overtones of a sound wave in an oscilloscope.
(e) Demonstrate the Doppler Effect using speaker and a microphone
(f) To demonstrate resonance with a set of coupled pendulums
(g) To demonstrate damping of a pendulum due to resistance of the medium
(h) To demonstrate formation of longitudinal and transverse waves
(i) To demonstrate reflection and transmission of waves at the boundary of two media
(j) To demonstrate the phenomenon of beats due to superposition of waves produced by two tuning forks of slightly different frequencies
(k) To demonstrate standing waves with a spring.

Suggested List of Experiments:

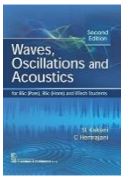
1. To study damped oscillations and dissipation of energy of a simple pendulum with time
2. To study of the spring constant of a helical spring from its load-extension graph.;

3. To study the normal modes of coupled pendulum and frequency splitting & coupling strength.
4. To determine the spring constant of a coupled pendulum under parallel/antiparallel oscillation.
5. To study the frequency and length of a wire under constant tension using a sonometer
6. To determine frequency of vibration of tunning forks by means of a sonometer.
7. To determine the frequency of alternating current using a sonometer and an electromagnet.
8. To determine the frequency of a tuning fork by Melde's experiment and verify $\lambda^2 - T$ law.
9. To determine the velocity of sound using Kundt's tube.
10. To determine the frequency of vibration of the tuning fork driving the string
11. To study normal modes of transverse vibration of a stretched string
12. To observe and measure standing waves on a string and determine the wave speed.
13. To investigate acoustic resonance in open and closed tubes and determine resonant frequencies.
14. To determine the velocity of sound using an oscilloscope.
15. To investigate the relationship between the frequency and phase of the two oscillating signals and how they influence the resulting Lissajous figures.

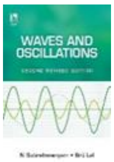
Minor Project:

A project on "Study the sound of 20 different types and compare their properties"

TEXT BOOKS

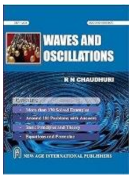


Name: Waves Oscillations and Acoustics
Author: S.L. Kakani and C Hemrajani
Edition: 2nd (2018)
Publisher: CBS publishers
ISBN: 978-9386827814

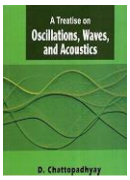


Name: Waves And Oscillations
Author: N. Subrahmanyam, Brij Lal
Edition: 2nd Ed.
Publisher: Vikas Publishing House Pvt Ltd
ISBN: 978-0706985436

REFERENCE BOOKS AND MATERIALS



Name: Waves and Oscillations
Author: R. N. Chaudhuri
Edition: 2010
Publisher: New Age Publishers
ISBN: 978-8122426793



Name: A Treatise on Oscillations, Waves and Acoustics
Author: D Chottopadhyay
Edition:
Publisher:
ISBN: 978-9384294748

6.0 0 MAPPING OF CLO TO PO AND PSO

The course outcomes and their mapping with program outcomes are specified in the table below

Course Learning Outcomes	Programme Outcomes (POs)												Programme Specific Outcome (PSOs)					
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6
CO1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

9.0 ASSESSMENT SCHEME

The evaluation system for this course consists of an 80% weightage on a comprehensive theory examination, which assesses students' understanding of various course topics, and a 20% weightage allocated to internal assessments, including internal examinations, assignments, class participation, and overall engagement in the course throughout the semester.

THEORY:

(A) Internal assessment: (20 marks): Continuous evaluation and internal assessment are implemented to foster and maintain a thorough understanding throughout the learning process. By regularly assessing comprehension through assignments, quizzes, and class participation, educators can address learning gaps promptly and support students in achieving deeper knowledge and proficiency in the subject matter.

(B) End-term examination (80 marks): The end-term examination serves as a culmination of students' learning in the course, assessing their comprehensive understanding and proficiency in various topics in the course. It provides a structured platform for students to demonstrate their knowledge, problem-solving abilities, and application of theoretical concepts, ultimately gauging their readiness to progress. Pattern of End term question paper

Section	Total Questions	Marks for each question	have to attempt	Total Marks
A	5	4	4	20
B	5	10	3	30
C	4	15	2	30

PRACTICUM:

(A) Internal assessment: (20 marks): In the internal assessment of the practicum components, the student's performance, understanding, skills, sincerity, and involvement in laboratory work during the entire semester are evaluated.

(B) End-term examination (80 marks): The ability to apply theoretical knowledge to real-world situations is the fundamental criterion used in the End Term examination. It typically involves students' activity on randomly assigned laboratory works and the Laboratory Report (Notebook) on the performed work in the entire semester. In the End examination, the student must complete randomly assigned tasks and prepare a report on their work, including appropriate conclusions. The mark distribution for the End term examination as follows.

Activity	Marks
Laboratory work in the Examination	40
Laboratory Notebook	20
Presentation/Viva-voce	20

PHY-001-CC-2120: OPTICS

NCrF Level:	5.0	
Programme:	Four Year Undergraduate Programme	**Semester:** Third
Course Category:	Major	
Credit (L: T: P)	3: 0: 2	
Credit Hours	Theory: 45 Hours, Practical: 60 Hours	

1.0 COURSE LEARNING OBJECTIVES

This course aims to equip students with a comprehensive understanding of the principles and applications of geometrical optics and physical optics. The Learning Outcomes of the Course are:

- Understand the fundamental nature and properties of light.
- Apply principles of geometrical optics to analyse and design optical systems.
- Utilize wave optics concepts to explain interference, diffraction, and polarization.
- Understand the principles and applications of modern optics, including lasers and holography.
- Conduct experiments to explore optical phenomena and interpret experimental data.

2.0 COURSE LEARNING OUTCOME

After completing this course, students will be able to,

CO	Outcomes
CO1:	Learn the principles and applications of geometrical optics, including ray theory, refraction, Gaussian formula, and matrix methods for analyzing lenses and optical systems.
CO2:	Gain a comprehensive understanding of light interference and its use to explain the operation in various optical components and systems.
CO3:	Learn principles of operation, types, and applications in various fields such as optics, metrology, and spectroscopy, and proficiency in designing and analysing interferometric systems.
CO4:	Acquire principles and mathematical formulations of diffraction and applications in optics to enable in analysing and designing optical systems with diffraction effects effectively.
CO5:	Understand the phenomena of polarization phenomena, and to analyse as well as to manipulate polarization effects in different optical components and devices effectively.
CO6:	Learn the principles of formation laser along with its characteristics and working mechanism of the practical laser system.
CO7:	Learn a comprehensive understanding on holographic recording techniques, reconstruction methods, and applications in imaging, display technology, and data storage.
CO8:	Develop the skill to use different optical components along with safety required safety considerations during the laboratory experiments.
CO9:	Gained practical skills in optical experimentation along with analyzing data, and applying theoretical concepts to real-world scenarios
CO10:	Able to prepare clear, structured, and concise scientific reports, effectively presenting laboratory works and findings with enhanced clarity.

3.0 SKILLS TO BE LEARNED

- To explain the variation of behavior of light in nature under different circumstances
- To distinguish between reflection, inference, diffraction and polarization of light in nature.
- To handle different optical components and lasers with necessary precautions.

4.0 DETAILED CONTENTS OF THE COURSE: THEORY

Credit: 3 **Classroom Teaching: 45 Hours**

MODULE 1

Geometrical Optics: Introduction to ray optics and ray theory, Fermat principle, Refraction from a single Interface, Gaussian Formula for a single spherical surface, Refraction from a double interface, Matric method in paraxial optics, thick and thin lens, system of lens, unit planes, nodal planes. **[6 hours]**

Interference of Light: Interference due to division of amplitude and division of wave front. Young's Double Slit experiment. Lloyd's Mirror and Fresnel's Biprism, Phase change on reflection: Stoke's treatment. Interference in thin films due to reflected and transmitted lights: parallel and wedge-shaped films. Fringes of equal inclination (Haidinger Fringes); Fringes of equal thickness (Fizeau Fringes). Newton's rings and its various aspects, Non-reflecting films, measurement of wavelength and refractive index **[9 hours]**

MODULE 2

Interferometers: Michelson's Interferometer – fringes formation mechanism (no theory needed), Determination of wavelength, Wavelength difference, Refractive index, and Visibility of fringes. Fabry-Perot interferometer. **[4 hours]**

Fraunhofer Diffraction: Diffraction at circular aperture and straight edge. Fraunhofer diffraction at a single slit and a double slit. Fraunhofer diffraction at N slits and its discussion. Plane diffraction grating and its theory, Dispersive power of grating, resolving power of optical instruments, Rayleigh criterion, Resolving power telescope, microscope, prism and diffraction grating. Phase contrast microscope. **[6 hours]**

Fresnel Diffraction: Fresnel's Assumptions. Fresnel's Half-Period Zones for Plane Wave. Explanation of Rectilinear Propagation of Light. Theory of a Zone Plate: Multiple Foci of a Zone Plate. Fresnel's Integral, Fresnel diffraction pattern of a straight edge, a slit and a wire. **[5 hours]**

MODULE 3

Kirchhoff's Integral Theorem: Fresnel-Kirchhoff's Integral formula (Qualitative discussion only) **[1 hours]**

Polarization: Introduction, Polarization by reflection, Brewster's law, Polarization by refraction, Malus's law, Double retraction, Nicol Prism and its use, elliptically and circularly polarized light, quarter and half wave plates, production and detection of plane, circularly and elliptically polarized light, optical activity, specific rotation, Half-shade polarimeter. **[7 hours]**

Laser: Absorption, Spontaneous Emission, Stimulated Emission, Principle of Laser action- Population inversion, characteristics of Laser Beams - Monochromaticity, Directionality, Brightness, Coherence (temporal & spatial), Focusability, construction and working of Ruby Laser and He-Ne Laser, **[5 hours]**

Principle of Holography: Recording and Reconstruction Method, Theory of Holography as Interference between two Plane Waves, Point Source Holograms. **[2 hours]**

5.0 DETAILED CONTENTS OF THE COURSE: PRACTICUM

Credit: 2 **Laboratory Work: 60 Hours**

In the practicum component of the course, students will undergo hands-on experience practical experience with optical instruments, enhance their understanding of light behavior, and develop skills in data analysis and scientific reporting.

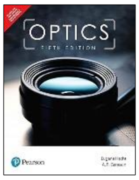
Students are required to conduct experiments from the provided list, meticulously following the suggested procedures and protocols outlined for each. Subsequently, they must compile comprehensive reports for every experiment, adhering to scientific standards and conventions. These reports should encompass a detailed description of the experimental setup and methodology employed, including any modifications made during the course of the experiment. Furthermore, students are expected to record and analyze their experimental data systematically, drawing upon relevant theoretical concepts and principles to interpret their findings accurately. Additionally, the reports should include a thorough discussion of the results obtained, highlighting any observed trends, anomalies, or correlations, and offering insightful explanations or hypotheses where applicable. Moreover, students must demonstrate proficiency in presenting their results graphically, utilizing tables, figures, and diagrams to enhance clarity and facilitate comprehension. Finally, each report should conclude with a succinct summary of the key findings and conclusions drawn from the experiment, along with any recommendations for further investigation or improvement.

The teacher has the flexibility to introduce a wide range of laboratory experiments that directly correlate with and reinforce the theoretical concepts covered in the course curriculum. These experiments serve as practical applications of the theoretical principles discussed in lectures.

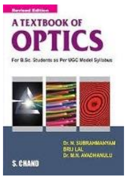
1. To determine the focal length of a combination of two convergent lenses separated by a distance and to verify the formula $\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2} - \frac{x}{f_1 f_2}$ where x is the distance of separation between the two lenses.
2. To use $\left(x, \frac{1}{F}\right)$ graph to find out the focal length of the combination:
    (a) When the two lens are in contact
    (b) When the systems would become telescopic
3. To determine the focal length of a convergent lens by modification of Newton's Equation $x_1 x_2 = f_1 f_2$
4. To determine the focal length of a diverging lens with a nodal slide.
5. To determine the refractive index of the material of the prism for a given wavelength of light.
6. To determine the refractive index of a liquid for a given wavelength with a spectrometer.
7. To determine the dispersive power of the material of a prism.
8. To study the variation of the angle of incidence for a prism and to use the incidence deviation graph for determining the refractive index of the material of the prism.
9. To determine the temperature of sodium flame.
10. To determine the wavelength of light with Fresnel's biprism
11. To determine the thickness of a given mica sheet by biprism method.
12. To determine the wavelength of sodium light by Newton's Rings method.
13. To determine the thickness of a thin paper by the interference of light in a wedge-shaped film.
14. To determine the wavelength of sodium light with a diffraction grating
15. To study the relation between the sine of the angel diffraction and the wavelength of light.
16. To use the grating in the position of minimum deviation for the determination of the wavelength of sodium light.
17. To determine the wavelength of light with a grating by measuring two deviations.
18. To determine the value of $\frac{d\theta}{d\lambda}$ for the grating
19. To determine the resolving power of a grating
20. To verify the expression for the resolving power of a telescope fitted with a variable rectangular aperture.
21. To determine the diameter of lycopodium particles by Corona rings method.

22. Familiarization with Schuster`s focusing determination of the angle of prism.
23. To determine the Refractive Index of the Material of a Prism using Sodium Light.
24. To determine Dispersive Power of the Material of a Prism using Mercury Light
25. To determine the value of Cauchy Constants.
26. To determine the Resolving Power of a Prism.
27. To determine wavelength of sodium light using Fresnel Biprism.
28. To determine wavelength of sodium light using Newton’s Rings.
29. To determine the wavelength of Laser light using Diffraction of Single Slit.
30. To determine wavelength of (1) Sodium and (2) Spectral lines of the Mercury light using plane diffraction grating
31. To determine the Resolving Power of a Plane Diffraction Grating.
32. To measure the intensity using photosensor and laser in diffraction patterns of single and double slits.

TEXT BOOKS

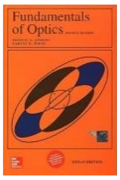


Name: Optics
Author: Eugene Hecht, A. R. Ganesan
Edition: 5th Ed.
Publisher: Pearson Education
ISBN: 978-9353439590

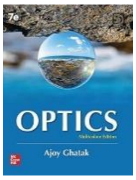


Name: A Textbook of Optics
Author: Brij Nandan Lal and N. Subrahmanyam
Edition: 23 Ed.
Publisher: S. Chand
ISBN: 978-8121926119

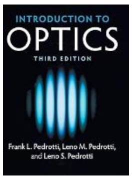
REFERENCE BOOKS AND MATERIALS



Name: Fundamentals of Optics
Author: Francis A. Jenkins and Harvey E. White
Edition: 4th Ed.
Publisher: McGraw Hill Education
ISBN: 978-1259002298



Name: Optics
Author: Ajoy Ghatak
Edition: 7th Ed.
Publisher: McGraw Hill
ISBN: 978-9390113590



Name: Introduction to Optics
Author: Frank L. Pedrotti, Leno M. Pedrotti , Leno S. Pedrotti
Edition: Cambridge University Press;
Publisher: 3rd Ed.
ISBN: 978-1108428262

6.0 MAPPING OF CLO TO PO AND PSO

The course outcomes and their mapping with program outcomes are specified in the table below

Course Learning Outcomes	Programme Outcomes (POs)												Programme Specific Outcome (PSOs)					
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6
CO1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

9.0 ASSESSMENT SCHEME

The evaluation system for this course consists of an 80% weightage on a comprehensive theory examination, which assesses students' understanding of various course topics, and a 20% weightage allocated to internal assessments, including internal examinations, assignments, class participation, and overall engagement in the course throughout the semester.

THEORY:

(A) Internal assessment: (20 marks): Continuous evaluation and internal assessment are implemented to foster and maintain a thorough understanding throughout the learning process. By regularly assessing comprehension through assignments, quizzes, and class participation, educators can address learning gaps promptly and support students in achieving deeper knowledge and proficiency in the subject matter.

(B) End-term examination (80 marks): The end-term examination serves as a culmination of students' learning in the course, assessing their comprehensive understanding and proficiency in various topics in the course. It provides a structured platform for students to demonstrate their knowledge, problem-solving abilities, and application of theoretical concepts, ultimately gauging their readiness to progress. Pattern of End term question paper

Section	Total Questions	Marks for each question	have to attempt	Total Marks
A	5	4	4	20
B	5	10	3	30
C	4	15	2	30

PRACTICUM:

(A) Internal assessment: (20 marks): In the internal assessment of the practicum components, the student's performance, understanding, skills, sincerity, and involvement in laboratory work during the entire semester are evaluated.

(B) End-term examination (80 marks): The ability to apply theoretical knowledge to real-world situations is the fundamental criterion used in the End Term examination. It typically involves students' activity on randomly assigned laboratory works and the Laboratory Report (Notebook) on the performed work in the entire semester. In the End examination, the student must complete randomly assigned tasks and prepare a report on their work, including appropriate conclusions. The mark distribution for the End term examination as follows.

Activity	Marks
Laboratory work in the Examination	40
Laboratory Notebook	20
Presentation/Viva-voce	20

PHY-001-CC-2210: MATHEMATICAL PHYSICS - II

NCrF Level: 5.0

Programme: Four Year Undergraduate Programme **Semester:** Fourth

Course Category: Major

Credit (L: T: P) 3: 0: 2

Credit Hours Theory: 45 Hours, Practical: 60 Hours

1.0 COURSE LEARNING OBJECTIVES

The emphasis of course is to equip students with the series solution and special functions in solving differential equations related to complex physical problems. The Learning Objectives of the course are:

- Develop the ability to solve differential equations using the power series method, understand and apply Legendre polynomials, and utilize special functions such as Bessel and Hermite functions in diverse physical and mathematical contexts.
- Understand and apply the Gamma and Beta functions to extend factorials to complex numbers, evaluate integrals, and solve advanced problems in mathematics and physics.
- Understand and apply Fourier series to represent periodic functions, analyze signal properties, and solve problems in physics.
- Understand and apply the Fourier and Laplace transforms to analyze and solve differential equations, represent signals, and transform functions between time and frequency domains.
- Using NumPy and SciPy for numerical computations entails harnessing their functionalities

2.0 COURSE LEARNING OUTCOME

After completing this course, students will be able to,

CO	Outcomes
CO1:	Understand and apply the power series method to solve ordinary differential equations, demonstrating proficiency in constructing and analyzing solutions for physical problems.
CO2:	Able to develop the ability to solve differential equations with regular singular points using the Frobenius series and understand the conditions for the convergence of these solutions.
CO3:	Gain a comprehensive understanding of special functions and their differential equations along with the skill to apply these functions to solve complex physical and mathematical problems.
CO4:	Understand the theoretical basis and practical applications of Fourier series which enable the students to decompose periodic functions and solve relevant problems
CO5:	Develop a solid understanding of matrices of different types and their operation which facilitate effective manipulation and analysis of matrices in physical contexts.
CO6:	Learn the proficiency in utilizing matrices to solve systems of linear equations, model transformations, and analyze data in various problems in physics.
CO7:	Learn the fundamentals of 'NumPy' and their applications in mathematical operation along with to apply in generating and plotting curves related to different physical systems.
CO8:	Learn to use NumPy, matplotlib and SciPy in mathematical compilation, data analysis, study of different physical phenomena and to solve real life problems of physics.
CO9:	Able to prepare clear, structured, and concise scientific reports, effectively presenting about the learned skill in the laboratory with enhanced clarity.

3.0 SKILLS TO BE LEARNED

- Utilizing differential equation with special functions and matrices for solving mathematical and physical problems across various filed of physics and engineering.
- Use of NumPy for efficient to demonstrate different physical phenomena, data analysis and to achieve tasks in various scientific and engineering disciplines.
- To formulate a physics problem and solve given mathematical equation risen out of it and find its solution using NumPy.

4.0 DETAILED CONTENTS OF THE COURSE: THEORY

Credit: 3 **Classroom Teaching: 45 Horus**

MODULE 1

Power series Method and Legendre polynomial: Power series solution of differential equations, Singular Points of Differential Equations and their importance, Series solution of differential equation, Frobenius method and its applications to differential equations. Legendre equation – general solution, Legendre functions $P_n(x)$ and $Q_n(x)$, properties of Legendre functions, Generating functions, Orthogonality, Recurrence formulae, Expansion of a function in a series of Legendre Polynomials. **[10 Lectures]**

Special Functions: Bessel equation and Bessel function $J_n(x)$, generating functions, recurrence relations, Orthogonality, Bessel function of second kind. Hermite Functions - Hermite differential equation, generating functions, Rodrigue formula, orthogonal property, Recurrence formula for $H_n(x)$, Laguerre's Functions- Laguerre's differential equation**,** Generating functions, orthogonality **[5 Lectures]**

MODULE 2

Special Integrals: Gamma function and its applications – Transformation of Gamma functions, Beta functions – evaluation, property, transformation. Relation between Beta and Gamma functions, Duplication formula, Expression of Integrals in terms of Gamma Functions – Dirichlet theoraem, Liouville's extension, error functions. **[9 Lectures]**

Fourier Series: Periodic functions and Fourier series and its applications, Dirichlet Conditions (Statement only). Determination of Fourier Coefficients (Euler's Formula), Expansion of periodic functions in a series of sine and cosine functions, Fourier series of discontinuous functions, Fourier series in Complex form, Practical Harmonic analysis. **[6 Lectures]**

MODULE 3

Fourier Transforms: Fourier Integral theorem. Fourier Transform. Examples. Fourier transform of trigonometric, Gaussian, finite wave train & other functions. Representation of Dirac delta function as a Fourier Integral. Fourier transform of derivatives, Inverse Fourier transform, Convolution theorem. Properties of Fourier transforms (translation, change of scale, complex conjugation, etc.). **[8 hours]**

Laplace Transforms: Laplace Transform (LT) of Elementary functions. Properties of LTs: Change of Scale Theorem, Shifting Theorem. LTs of 1st and 2nd order Derivatives and Integrals of Functions, Derivatives and Integrals of LTs. LT of Unit Step function, Dirac Delta function, Periodic Functions. Convolution Theorem. Inverse LT. **[7 hours]**

5.0 DETAILED CONTENTS OF THE COURSE: PRACTICUM

Credit: 2 **Laboratory Work: 60 Hours**

In the practicum component of the course students learn basics of python and its libraries like NumPy, SciPy, Matplotlib during the laboratory classes. They have to go through exercise related to the use of the function of these libraries. They have to apply these programming skills and library functions in mathematical computation, numerical calculations in the laboratory classes.

(a) **Review on Python:** Concepts of programming and algorithm, flowchart, python IDE - Anaconda, Spyder, Jupyter notebooks, Python syntax, data types, and operators, Python scripts, conditional statements (if-else) and loops (for, while) lists, tuples, dictionaries, and sets, reading from and writing to files in Python, Python Libraries and Modules NumPy, SciPy, Matplotlib, Pandas etc

(b) **NumPy Fundamentals:** Overview of NumPy and its importance, Installing and importing NumPy, NumPy documentation and resources, Difference between List and NumPy array, Creating NumPy arrays from lists and other data structures, Array attributes and data types, Basic Array Operations – indexing, slicing, iterating over arrays, Basic arithmetic operations on arrays, reshaping and resizing arrays, creating arrays using ones(), zeros(), random(), arange(), linspace(), multidimensional arrays – matrix operation and multidimensional arrays. Input and output with NumPy – Reading and writing to files, handling different file formats (CSC, binary etc.)

(c) Matplotlib: Overview of Matplotlib and its importance, Installing and importing Matplotlib, Basic Plotting - Line plots, scatter plots, and bar charts, Figure and Axes objects - creating subplots and multiple axes, Histograms, pie charts, and box plots, working with colours, markers, and line styles, Using stylesheets and themes, Integrating Matplotlib with Pandas Data frames, plotting directly from pandas objects. Creating interactive plots using widgets, Integrating Matplotlib with interactive environments like Jupyter Notebook, 3D Plotting **–** surface plots and 3D visualizations, saving plots to different file formats, Customizing export settings for publication-quality figures

(d) **SciPy Fundamentals:** Overview of SciPy and its importance, Installing and importing SciPy, Linear Algebra with SciPy - Solving linear systems of equations, Eigenvalues and eigenvectors, matrix decomposition, optimization and root finding, Numerical integration using SciPy, solving ordinary differential equation, interpolation and curve fitting using SciPy, input and output with SciPy.

(e) **Generation of Special functions**: Generating and plotting Legendre Polynomials Generating and plotting Bessel function.

Suggestive exercise of NumPy Library

(a) NumPy Basic

1. Write a NumPy program to get the NumPy version and show the NumPy build configuration.
2. Write a NumPy program to get help with the add function.
3. Write a NumPy program to test whether none of the elements of a given array are zero.
4. Write a NumPy program to test if any of the elements of a given array are non-zero.
5. Write a NumPy program to test a given array element-wise for finiteness (not infinity or not a number).
6. Write a NumPy program to test elements-wise for positive or negative infinity.
7. Write a NumPy program to test element-wise for 'NaN' of a given array.
8. Write a NumPy program to test element-wise for complex numbers, real numbers in a given array. Also test if a given number is of a scalar type or not.
9. Write a NumPy program to test whether two arrays are element-wise equal within a tolerance.
10. Write a NumPy program to create an element-wise comparison (greater, greater equal, less and less equal) of two given arrays.
11. Write a NumPy program to create an element-wise comparison (equal, equal within a tolerance) of two given arrays.
12. Write a NumPy program to create an array with the values 1, 7, 13, 105 and determine the size of the memory occupied by the array.
13. Write a NumPy program to create an array of 10 zeros, 10 ones, and 10 fives.
14. Write a NumPy program to create an array of integers from 30 to 70.
15. Write a NumPy program to create an array of all even integers from 30 to 70.
16. Write a NumPy program to create a 3x3 identity matrix.
17. Write a NumPy program to generate a random number between 0 and 1.
18. Write a NumPy program to generate an array of 15 random numbers from a standard normal distribution.

19. Write a NumPy program to create a vector with values ranging from 15 to 55 and print all values except the first and last.
20. Write a NumPy program to create a 3X4 array and iterate over it.
21. Write a NumPy program to create a vector of length 10 with values evenly distributed between 5 and 50.
22. Write a NumPy program to create a vector with values from 0 to 20 and change the sign of the numbers in the range from 9 to 15.
23. Write a NumPy program to create a vector of length 5 filled with arbitrary integers from 0 to 10.
24. Write a NumPy program to multiply the values of two given vectors.
25. Write a NumPy program to create a 3x4 matrix filled with values from 10 to 21.
26. Write a NumPy program to find the number of rows and columns in a given matrix.
27. Write a NumPy program to create a 3x3 identity matrix, i.e. the diagonal elements are 1, the rest are 0.
28. Write a NumPy program to create a 10x10 matrix, in which the elements on the borders will be equal to 1, and inside 0.
29. Write a NumPy program to create a 5x5 zero matrix with elements on the main diagonal equal to 1, 2, 3, 4, 5.
30. Write a NumPy program to create a 4x4 matrix in which 0 and 1 are staggered, with zeros on the main diagonal.
31. Write a NumPy program to create a 3x3x3 array filled with arbitrary values.
32. Write a NumPy program to compute the sum of all elements, the sum of each column and the sum of each row in a given array.
33. Write a NumPy program to compute the inner product of two given vectors.
34. Write a NumPy program to add a vector to each row of a given matrix.
35. Write a NumPy program to save a given array to a binary file.
36. Write a NumPy program to save a given array to a binary file.
37. Write a NumPy program to save a given array to a text file and load it.
38. Write a NumPy program to convert a given array into bytes, and load it as an array.
39. Write a NumPy program to convert a given list into an array, then again convert it into a list. Check if initial list and final list are equal or not.
40. Write a NumPy program to compute the x and y coordinates for points on a sine curve and plot the points using matplotlib.
41. Write a NumPy program to convert numpy dtypes to native Python types
42. Write a NumPy program to add elements to a matrix. If an element in the matrix is 0, we will not add the element below this element.
43. Write a NumPy program to find missing data in a given array.
44. Write a NumPy program to check whether two arrays are equal (element wise) or not.
45. Write a NumPy program to create a one-dimensional array of single, two and three-digit numbers.
46. Write a NumPy program to create a two-dimensional array of a specified format.
47. Write a NumPy program to create a one-dimensional array of forty pseudo-randomly generated values. Select random numbers from a uniform distribution between 0 and 1.
48. Write a NumPy program to create a two-dimensional array with shape (8,5) of random numbers. Select random numbers from a normal distribution (200,7).
49. Write a NumPy program to generate a uniform, non-uniform random sample from a given 1-D array with and without replacement.
50. Write a NumPy program to create a 4x4 array with random values. Create an array from the said array swapping first and last rows.
51. Write a NumPy program to create a new array of given shape (5,6) and type, filled with zeros.

52. Write a NumPy program to sort a given array by row and column in ascending order.
53. Write a NumPy program to extract all numbers from a given array less and greater than a specified number.
54. Write a NumPy program to replace all numbers in a given array equal, less and greater than a given number.

55. Write a NumPy program to create an array of equal shape and data type for a given array.
56. Write a NumPy program to create a three-dimensional array with the shape (3,5,4) and set it to a variable.
57. Write a NumPy program to create a 4x4 array. Create an array from said array by swapping first and last, second and third columns.
58. Write a NumPy program to swap rows and columns of a given array in reverse order.
59. Write a NumPy program to multiply two given arrays of the same size element-by-element.

(b) NumPy Linear Algebra

1. Write a NumPy program to compute the multiplication of two given matrixces.
2. Write a NumPy program to compute the outer product of two given vectors.
3. Write a NumPy program to compute the cross product of two given vectors.
4. Write a NumPy program to compute the determinant of a given square array.
5. Write a NumPy program to evaluate Einstein's summation convention of two given multidimensional arrays.
6. Write a NumPy program to compute the inner product of vectors for 1-D arrays (without complex conjugation) and in higher dimension.
7. Write a NumPy program to compute the eigenvalues and right eigenvectors of a given square array.
8. Write a NumPy program to compute the Kronecker product of two given multidimension arrays.
9. Write a NumPy program to compute the condition number of a given matrix.
10. Write a NumPy program to find a matrix or vector norm.
11. Write a NumPy program to compute the determinant of an array.
12. Write a NumPy program to compute the inverse of a given matrix.
13. Write a NumPy program to calculate the QR decomposition of a given matrix.
14. Write a NumPy program to compute the condition number of a given matrix.
15. Write a NumPy program to compute the sum of the diagonal element of a given array.
16. Write a NumPy program to get the lower-triangular L in the Cholesky decomposition of a given array.
17. Write a NumPy program to get the qr factorization of a given array.
18. Write a NumPy program to compute the factor of a given array by Singular Value Decomposition.
19. Write a NumPy program to calculate the Frobenius norm and the condition number of a given array.

(c) NumPy Random:

1. Write a NumPy program to generate five random numbers from the normal distribution.
2. Write a NumPy program to generate six random integers between 10 and 30.
3. Write a NumPy program to create a 3x3x3 array with random values.
4. Write a NumPy program to create a 5x5 array with random values and find the minimum and maximum values.
5. Write a NumPy program to create a random 10x4 array and extract the first five rows of the array and store them into a variable.
6. Write a NumPy program to shuffle numbers between 0 and 10 (inclusive).
7. Write a NumPy program to normalize a 3x3 random matrix.
8. Write a NumPy program to create a random vector of size 10 and sort it.
9. Write a NumPy program to find the nearest value from a given value in an array.
10. Write a NumPy program to check if two random arrays are equal or not.
11. Write a NumPy program to create a random vector of size 15 and replace the maximum value by -1.
12. Write a NumPy program to find point by point distances of a random vector with shape (10,2) representing coordinates.
13. Write a NumPy program to find the most frequent value in an array.
14. Write a NumPy program to convert cartesian coordinates to polar coordinates of a random 10x2 matrix representing cartesian coordinates.
15. Write a NumPy program to find the closest value (to a given scalar) in an array.
16. Write a NumPy program to get the n largest values of an array.

17. Write a NumPy program to create a three-dimensional array with shape (300,400,5) and set to a variable. Fill the array elements with values using unsigned integers (0 to 255).

(d) Sorting and Searching:

1. Write a NumPy program to sort a given array of shape 2 along the first axis, last axis and flattened array.
2. Write a NumPy program to create a structured array from given student name, height, class and their data types. Now sort the array on height.
3. Write a NumPy program to create a structured array from given student name, height, class and their data types. Now sort by class, then height if class is equal.
4. Write a NumPy program to sort the student id with increasing height of the students from given students id and height. Print the integer indices that describe the sort order by multiple columns and the sorted data.
5. Write a NumPy program to get the indices of the sorted elements of a given array.
6. Write a NumPy program to sort a given complex array using the real part first, then the imaginary part.
7. Write a NumPy program to partition a given array in a specified position and move all the smaller elements values to the left of the partition, and the remaining values to the right, in arbitrary order (based on random choice).
8. Write a NumPy program to sort the specified number of elements from the beginning of a given array.
9. Write a NumPy program to sort a given array by the nth column.

(e) NumPy Mathematics:

1. Write a NumPy program to add, subtract, multiply, divide arguments element-wise.
2. Write a NumPy program to compute logarithm of the sum of exponentiations of the inputs, sum of exponentiations of the inputs in base-2.
3. Write a NumPy program to get true division of the element-wise array inputs.
4. Write a NumPy program to get the largest integer smaller or equal to the division of the inputs.
5. Write a NumPy program to get the powers of an array values element-wise.
6. Write a NumPy program to get the element-wise remainder of an array of division.
7. Write a NumPy program to calculate the absolute value element-wise.
8. Write a NumPy program to round array elements to the given number of decimals.
9. Write a NumPy program to round elements of the array to the nearest integer.
10. Write a NumPy program to get the floor, ceiling and truncated values of the elements of a numpy array.
11. Write a NumPy program to multiply a 5x3 matrix by a 3x2 matrix and create a real matrix product.
12. Write a NumPy program to multiply a matrix by another matrix of complex numbers and create a new matrix of complex numbers.
13. Write a NumPy program to create an inner product of two arrays
14. Write a NumPy program to generate inner, outer, and cross products of matrices and vectors.
15. Write a NumPy program to generate a matrix product of two arrays.
16. Write a NumPy program to find the roots of the following polynomials.
    (i) $x^2 - 4x = 7$
    (ii) $x^4 - 11x^3 + 9x^2 + 11x = 10$
17. Write a NumPy program to compute the following polynomial values for $x = 2$ and $x = 3$
    (i) $x^2 - 4x - 7$
    (ii) $x^4 - 11x^3 + 9x^2 + 11x - 10$
18. Write a NumPy program to add one polynomial to another, subtract one polynomial from another, multiply one polynomial by another and divide one polynomial by another.
19. Write a NumPy program to calculate mean across dimension, in a 2D NumPy array.
20. Write a NumPy program to create a random array with 1000 elements and compute the average, variance, standard deviation of the array elements.
21. Write a NumPy program to compute the trigonometric sine, cosine and tangent array of angles given in degrees.
22. Write a NumPy program to calculate inverse sine, inverse cosine, and inverse tangent for all elements in a given array
23. Write a NumPy program to convert angles from radians to degrees for all elements in a given array.

24. Write a NumPy program to convert angles from degrees to radians for all elements in a given array.
25. Write a NumPy program to calculate hyperbolic sine, hyperbolic cosine, and hyperbolic tangent for all elements in a given array.
26. Write a NumPy program to calculate round, floor, ceiling, truncated and round (to the given number of decimals) of the input, element-wise of a given array.
27. Write a NumPy program to calculate the cumulative sum of the elements along a given axis, sum over rows for each of the 3 columns and sum over columns for each of the 2 rows of a given 3x3 array.
28. Write a NumPy program to calculate cumulative product of the elements along a given axis, sum over rows for each of the 3 columns and product over columns for each of the 2 rows of a given 3x3 array.
29. Write a NumPy program to calculate the difference between neighboring elements, element-wise of a given array.
30. Write a NumPy program to calculate the difference between neighboring elements, element-wise, and prepend [0, 0] and append[200] to a given array
31. Write a NumPy program to compute e^x, element-wise given array.
32. Write a NumPy program to calculate $e^x - 1$ for all elements in a given array.
33. Write a NumPy program to calculate 2p for all elements in a given array.
34. Write a NumPy program to compute natural, base 10, and base 2 logarithms for all elements in a given array.
35. Write a NumPy program to compute the natural logarithm of one plus each element of a given array in floating-point accuracy.
36. Write a NumPy program to check element-wise True/False of a given array where the sign bit is set.
37. Write a NumPy program to change the sign of a given array to that of a given array, element-wise
38. Write a NumPy program to compute numerical negative values for all elements in a given array.
39. Write a NumPy program to compute the reciprocal for all elements in a given array.
40. Write a NumPy program to compute xy, element-wise where x, y are two given arrays.
41. Write a NumPy program to compute an element-wise indication of the sign for all elements in a given array.

(f) NumPy String

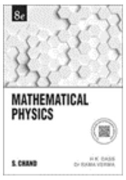
1. Write a NumPy program to concatenate element-wise two arrays of string.
2. Write a NumPy program to repeat all the elements three times of a given array of string
3. Write a NumPy program to capitalize the first letter, lowercase, uppercase, swapcase, title-case of all the elements of a given array.
4. Write a NumPy program to make the length of each element 15 of a given array and the string centered / left-justified / right-justified with paddings of _Original Array: ['python exercises', 'PHP', 'java', 'C++']
5. Write a NumPy program to encode all the elements of a given array in cp500 and decode it again.
6. Write a NumPy program to remove the leading and trailing whitespaces of all the elements of a given array.
7. Write a NumPy program to remove the leading whitespaces of all the elements of a given array.

Suggestive list for exercise: Matplotlib

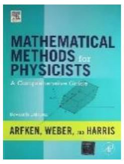
1. Write a Python program to draw a line with a suitable label in the x axis, y axis and a title.
2. Write a Python program to draw a line using given axis values with suitable labels in the x axis , y axis and a title.
3. Write a Python program to draw a line using given axis values taken from a text file, with suitable labels in the x axis, y axis and a title.
4. Write a Python program to draw line charts of the experimental data .
5. Write a Python program to plot two or more lines on the same plot with suitable legends of each line.
6. Write a Python program to plot two or more lines with legends, different widths and colors.
7. Write a Python program to plot two or more lines with different styles.
8. Write a Python program to plot two or more lines and set the line markers.
9. Write a Python program to display the current axis limits values and set new axis values.

10. Write a Python program to plot quantities which have an x and y position.
11. Write a Python program to plot several lines with different format styles in one command using arrays.
12. Write a Python program to create multiple types of charts (a simple curve and plot some quantities) on a single set of axes.
13. Write a Python program to display the grid and draw line charts of the data of an experiment and customize the grid lines with line-style -, width 0.5 and color blue.
14. Write a Python program to display the grid and draw line charts of data of an experiment. Customized the grid lines with rendering with a larger grid (major grid) and a smaller grid (minor grid). Turn on the grid but turn off ticks.
15. Write a Python program to create multiple plots of different data sets in a single chart.
16. Write a Python program to display a bar chart of the temperature of your location in the last 7 days.
17. Write a Python program to display a horizontal bar chart of the temperature of your location in the last 7 days.
18. Write a Python programming to display a bar chart of Languages the temperature of your location in the last 7 days. Use a different color for each bar.
19. Write a Python programming to display a bar chart of Languages the temperature of your location in the last 7 days. Attach a text label above each bar and mention the curve.
20. Write a Python programming to display a bar chart of Languages the temperature of your location in the last 7 days. Make a blue border to each bar.
21. Write a Python programming to display a bar chart of Languages the temperature of your location in the last 7 days. Specify the position of each bar plot.
22. Write a Python programming to display a bar chart of Languages the temperature of your location in the last 7 days. Select the width of each bar and their positions.
23. Write a Python programming to display a bar chart of Languages the temperature of your location in the last 7 days. Increase bottom margin.
24. Write a Python program to display a bar chart of Languages the temperature of two locations in the last 7 days in the same chart.
25. Write a Python program to create bar plot from a Data Frame (temperature of five locations in the same chart)
26. Write a Python program to create bar plots with error bars for a data set of an experiment. Attach text level in each bar.
27. Write a Python program to create a stacked bar plot with error bars.
28. Write a Python program to create a horizontal bar chart with differently ordered colors.
29. Write a Python program to create stacked bar plots and add labels to each section.
30. Write a Python program to add textures (black and white) to bars and wedges.
31. Write Python programming to create a pie chart of a data set.
32. Write Python programming to create a pie chart with detailed information about the chart.
33. Write Python programming to create a pie chart with detailed information about the chart. Make multiple wedges of the pie
34. Write a Python programming to create a pie chart by reading data from a csv file
35. Write a Python program to draw a scatter graph taking a random distribution in X and Y and plotting against each other.
36. Write a Python program to draw a scatter plot with empty circles taking a random distribution in X and Y and plotted against each other.
37. Write a Python program to draw a scatter plot using random distributions to generate balls of different sizes.
38. Write a Python program to draw a scatter plot comparing two subject marks.
39. Write a Python program to draw a scatter plot for three different groups comparing weights and heights.
40. Write a Python program to draw a scatter plot to find sea level rise in the past 100 years.

6.0 TEXT BOOKS

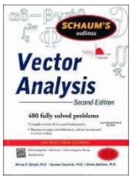


Name: Mathematical Physics
Author: H.K. Dass and R. Verma
Edition: 8^{th} Ed. (2022)
Publisher: S. Chand & Company.
ISBN: 978-9352837229

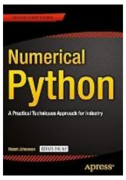


Name: Mathematical Methods for Physicists,
Author: G.B. Arfken, H.J. Weber, F.E. Harris
Edition: 7^{th} Edn
Publisher: Elsevier
ISBN: 978-9381269558

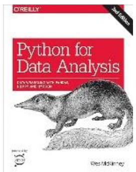
7.0 REFERENCE BOOKS AND MATERIALS



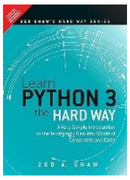
Name: Schaum's Outline of Vector Analysis
Author: Spiegel Murray
Edition: 2^{nd} Ed (2009).
Publisher: McGraw-Hill Education, India
ISBN: 978-0071615457



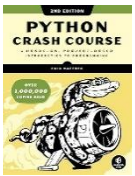
Name: Numerical Python: A Practical Techniques Approach for Industry
Author: Robert Johansson
Edition: 1st
Publisher: Springer Nature
ISBN: 978-1484205549



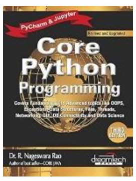
Name: Python for Data: Data Wrangling with Pandas, NumPy, and IPython
Author: Wes Mckinney
Edition: 2nd edition
Publisher: O'Reilly
ISBN: 978-1491957660



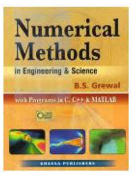
Name: Learn More Python 3 the Hard Way: The Next Step for New Python Programmers
Author: Zed Shaw
Edition:
Publisher:
ISBN: 978-9352865109



Name: Python Crash Course
Author: Eric Matthes
Edition: 2^{nd} Ed (2019)
Publisher: No Starch Press
ISBN: 9781718502703



Name: Core Python Programming
Author: R. Nageswara Rao
Edition: 3^{rd}
Publisher: Wiley India Pvt Ltd.
ISBN: 978-9390457151



Name: Numerical Methods in Engineering & Science
Author: B. S. Grewal
Edition: 10^{th} Ed.
Publisher: Khanna Publishers
ISBN: 9788174092489

6.0 0 MAPPING OF CLO TO PO AND PSO

The course outcomes and their mapping with program outcomes are specified in the table below

Course Learning Outcomes	Programme Outcomes (POs)												Programme Specific Outcome (PSOs)					
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6
CO1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

9.0 ASSESSMENT SCHEME

The evaluation system for this course consists of an 80% weightage on a comprehensive theory examination, which assesses students' understanding of various course topics, and a 20% weightage allocated to internal assessments, including internal examinations, assignments, class participation, and overall engagement in the course throughout the semester.

THEORY:

(A) Internal assessment: (20 marks): Continuous evaluation and internal assessment are implemented to foster and maintain a thorough understanding throughout the learning process. By regularly assessing comprehension through assignments, quizzes, and class participation, educators can address learning gaps promptly and support students in achieving deeper knowledge and proficiency in the subject matter.

(B) End-term examination (80 marks): The end-term examination serves as a culmination of students' learning in the course, assessing their comprehensive understanding and proficiency in various topics in the course. It provides a structured platform for students to demonstrate their knowledge, problem-solving abilities, and application of theoretical concepts, ultimately gauging their readiness to progress. Pattern of End term question paper

Section	Total Questions	Marks for each question	have to attempt	Total Marks
A	5	4	4	20
B	5	10	3	30
C	4	15	2	30

PRACTICUM:

(A) Internal assessment: (20 marks): In the internal assessment of the practicum components, the student's performance, understanding, skills, sincerity, and involvement in laboratory work during the entire semester are evaluated.

(B) End-term examination (80 marks): The ability to apply theoretical knowledge to real-world situations is the fundamental criterion used in the End Term examination. It typically involves students' activity on randomly assigned laboratory works and the Laboratory Report (Notebook) on the performed work in the entire semester. In the End examination, the student must complete randomly assigned tasks and prepare a report on their work, including appropriate conclusions. The mark distribution for the End term examination as follows.

Activity	Marks
Laboratory work in the Examination	40
Laboratory Notebook	20
Presentation/Viva-voce	20

PHY-001-CC-2220: ELECTRICITY AND MAGNETISM

NCrF Level:	5.0		
Programme:	Four Year Undergraduate Programme	**Semester:**	Fourth
Course Category:	Major		
Credit (L: T: P)	3: 0: 1		
Credit Hours	Theory: 45 Hours, Practical: 30 Hours		

1.0 COURSE LEARNING OBJECTIVES

The course aims to provide students with a thorough understanding of the fundamental principles of electricity and magnetism, including electric fields, magnetic fields, and electric currents. The Learning Objectives of the course are:

- Understand the concept of electric fields to solve electrostatics problems.
- Analyze the behavior of conductors, dielectrics, and capacitance in various configurations.
- Explain the principles of magnetostatics and analyze the behavior of magnetic materials.
- Understand and apply Faraday's law of induction
- Fundamental of Maxwell's equations and electromagnetic waves.
- Solve problems involving electric currents, Ohm's law, and circuits.
- Perform and interpret laboratory experiments related to electric and magnetic fields, circuits, and electromagnetism.

2.0 COURSE LEARNING OUTCOME

After completing this course, students will be able to,

CO	Outcomes
CO1:	Learn the principles of electrostatics and associated laws along with the skill to solve problems charge distribution in various geometries
CO2:	Able to use the concept of electrostatics in capacitors, dielectrics, and understand their significance in technology in practical scenarios.
CO3:	Understand and to apply the fundamental principles of magnetostatics and the laws associated with it for calculating magnetic fields generated by various current configurations.
CO4:	Able to understand the concept of electromagnetic induction and understanding the principles behind transformers and electric generators.
CO5:	Learn the unification of the fundamental laws into Maxwell's equations, their physical significance and the concept behind the prediction of electromagnetic waves.
CO6:	Learn the fundamental laws and behaviour of circuit elements in DC circuits enabling them to analyze diverse electronic systems with precision.
CO7:	Gain a comprehensive understanding of alternating current (AC) theory and skill to analyze basic ac circuits using phasors, impedance and complex numbers.
CO8:	Develop practical skills to verify different principles of electromagnetic induction and electric circuit to reinforce the theoretical concept in the laboratory.
CO9:	Gain hands-on experience in constructing and testing various DC and AC circuit configurations, reinforcing theoretical concepts and enhancing problem-solving abilities in the laboratory.
CO10:	Able to prepare clear, structured, and concise scientific reports, effectively presenting laboratory works and findings with enhanced clarity.

3.0 SKILLS TO BE LEARNED

- To solving problems related to electric and magnetic fields in static situations.
- To frame Maxwell's equations in various contexts
- To apply concepts of electricity and magnetism to practical problems,
- To use electronic measurement instruments.

4.0 DETAILED CONTENTS OF THE COURSE: THEORY

Credit: 3 **Classroom Teaching: 45 Horus**

MODULE 1

Electrostatics: Electric field and electrostatic potential for charge distribution, Electric field due to a line charge, surface charge and volume charge. Flux of electric field and Gauss Law - Differential and integral forms, Divergence of electric field using Dirac Delta function, scalar potential, Ambiguities of Electric potential, Applications of Gauss's Law to various charge distributions with spherical, cylindrical and planar symmetries. Laplace's and Poisson's equations, The Method of Images is applied to a system of a point charge and finite continuous charge distribution (line charge and surface charge) in the presence of (i) a Plane infinite sheet maintained at constant potential, and (ii) a Sphere maintained at constant potential, electric dipole, quadrupole, multipole expansion. Electrostatics in dielectrics – Gauss' law, displacement vector, Susceptibility, permittivity and dielectric constant, Laplace's and Poisson's equations in dielectrics, Electrostatic energy of a charged sphere - Parallel-plate, cylindrical and spherical capacitor. **[15 hours]**

MODULE 2

Magnetic Field: Magnetic field due to arbitrary current, Biot-Savart Law and its applications, straight wire and circular loop, divergence and curl of magnetic field, Magnetic vector potential and calculation for different current densities, Ampere's law – differential and integral form, Application of Ampere's Law - Solenoid, Toroid etc. Magnetic scalar potential. **[7 hours]**

Magnetostatics In a linear magnetic medium: Magnetization vector. Bound currents, Magnetic intensity. auxiliary magnetic field, Magnetic susceptibility and permeability, Relation between B, H, M, Diamagnetic, paramagnetic and ferromagnetic materials, Hund's rule, B-H curve and hysteresis, Differential and integral form of Ampere's Law in the presence of magnetized materials. **[4 hours]**

Electromagnetic Induction and Faraday's law: Faraday's law and induced emf, calculation of self-Inductance, Mutual Inductance – coefficient of coupling, series and parallel inductance, Energy stored in a Magnetic Field, Magnetic Force on current carrying wires, Torque on a current loop in a uniform Magnetic Field- applications, Ballistic galvanometer, Eddy currents and electromagnetic damping, Electromagnetic braking, **[4 hours]**

MODULE 3

Maxwell's Equation and Electromagnetic waves: Displacement current and its significance, Modification of Ampere's Law by Maxwell, Derivation of wave equations from Maxwell's Equations, Plane electromagnetic waves in vacuum, their transverse nature and polarization; relation between electric and magnetic fields; Flow of energy and Poynting vector. [**3 Lectures]**

DC currents: Ohm's Law, Kirchhoff's Voltage Law and Kirchhoff's current laws, current through resistance(R), inductance(L), capacitance(C), combination of R, L and C, Transient analysis – growth and decay of currents in LR circuit, Charging and discharging of capacitor in RC circuits, LCR circuit, discharge of capacitor through pure inductor (LC circuit) – electric oscillation. [**5 Hours]**

AC Circuits: Sinusoidal voltage and current - instantaneous, peak to peak, root mean square and average value, form factor and peak factor, Power and wattless components of AC current, voltage-current relationship in resistor, inductor and capacitor, phasor, complex impedance, AC current in RL, RC circuit and LCR circuit (series and parallel)- Frequency Response, Bandwidth, Quality Factor – transformer loss. Half wave and full wave rectifier circuits and their characteristics [**7 Hours]**

5.0 DETAILED CONTENTS OF THE COURSE: PRACTICUM

Credit: 1 **Laboratory Work: 30 Hours**

In the practicum component of the course, students will undergo experiments related to electricity and magnetism. During the experiments they have hands-on experience with electronic measuring instruments. The experiment should have studied fundamental principles and laws associated with electricity and magnetism. Students are required to conduct experiments from the provided list, meticulously following the suggested procedures and protocols outlined for each. Subsequently, they must compile comprehensive reports for every experiment, adhering to scientific standards and conventions. These reports should encompass a detailed description of the experimental setup and methodology employed, including any modifications made during the course of the experiment. Furthermore, students are expected to record and analyze their experimental data systematically, drawing upon relevant theoretical concepts and principles to interpret their findings accurately. Additionally, the reports should include a thorough discussion of the results obtained, highlighting any observed trends, anomalies, or correlations, and offering insightful explanations or hypotheses where applicable. Moreover, students must demonstrate proficiency in presenting their results graphically, utilizing tables, figures, and diagrams to enhance clarity and facilitate comprehension. Finally, each report should conclude with a succinct summary of the key findings and conclusions drawn from the experiment, along with any recommendations for further investigation or improvement.

The teacher has the flexibility to introduce a wide range of laboratory experiments that directly correlate with and reinforce the theoretical concepts covered in the course curriculum. These experiments serve as practical applications of the theoretical principles discussed in lectures.

(A) Laboratory Activity:

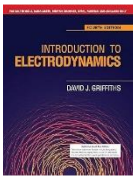
1. To assemble the components of a given electrical circuit.
2. To draw the diagram of a given open circuit comprising at least a battery, resistor/rheostat, key, ammeter and voltmeter. Mark the components that are not connected in proper order and correct the circuit and also the circuit diagram.
3. To measure the resistance and impedance of an inductor with or without iron core.
4. To measure resistance, voltage (dc/ac), current (dc) and check continuity of a given circuit using a multimeter.
5. To assemble a household circuit comprising three bulbs, three (on/off) switches, a fuse and a power source.
6. To study the variation in potential drop with length of a wire for a steady current.
7. Charging and discharging of capacitor in RC circuit.
8. Use an oscilloscope to measure AC voltage and current and compare RMS, peak and average values for sinusoidal signals
9. Measure and calculate the impedance of resistors, inductors, and capacitors in AC circuits and analyze phase relationships between voltage and currents.
10. Construct series and parallel RLC circuits and measure impedance, resonance frequency, and phase angle.
11. Construct and analyze the operation of AC bridge circuits, such as the Wheatstone bridge and Measure unknown impedances using bridge balance conditions
12. Study the characteristics of transformers, including turns ratio, voltage regulation, and efficiency and measure primary and secondary voltages and currents.
13. Analyze the transient response of RL circuits when switching AC sources.
14. Measure time constants and compare with theoretical predictions.
15. Use an LCR meter to measure the inductance, capacitance, and resistance of AC circuit components and compare measured values with theoretical calculations.

16. Design and construct active and passive filters (low-pass, high-pass, band-pass, and band-stop) and measure and analyze the frequency response and attenuation.

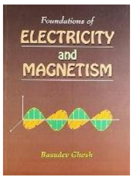
(B) Suggestive list of Experiments:

1. To determine resistance per unit length of a given wire by plotting a graph of potential difference versus current.
2. To determine the resistance of a given wire using a meter bridge and hence determine the resistivity of the material of the wire.
3. To compare the emf of two given primary cells (Daniel and Leclanche cells) using a potentiometer.
4. To determine the internal resistance of a given primary cell using a potentiometer.
5. To determine the resistance of a galvanometer by half-deflection method and to find its figure of merit.
6. To convert the given galvanometer (of known resistance and figure of merit) into (i) an ammeter of a desired range (say 0 to 30 mA) and (ii) a voltmeter of desired range (say 0 to 3 V) and to verify the same.
7. Verify ohm's law, Kirchhoff's Voltage Law and Kirchhoff's current laws in a dc circuit.
8. Study the charging and discharging of capacitors in RC circuits and measure time constants and compare with theoretical values.
9. Analyze the transient response of inductors in RL circuits and measure time constants and compare with theoretical predictions.
10. Investigate the resonance in series and parallel RLC circuits and measure resonant frequency, bandwidth, and quality factor.
11. Analyze AC circuits using phasors and impedance and measure voltage and current in R, L, and C components.
12. study the frequency response and cut-off frequencies and Construct Bode plots from experimental data.
13. Construct and analyze Wheatstone and Maxwell bridges and measure unknown resistances and inductances.
14. Measure power factor in inductive and capacitive circuits and Implement power factor correction using capacitors.
15. Study the principles of mutual inductance and measure voltage transformation ratio and efficiency in transformers.
16. To study of resonance in series RLC circuit and determine its Q factor
17. To study of resonance in parallel RLC circuit and determine its Q factor

6.0 TEXT BOOKS

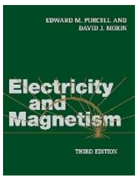


Name: Introduction to Electrodynamics
Author: David J. Griffiths
Edition: 4th Ed. (2020)
Publisher: Cambridge University Press
ISBN: 978-1108822909

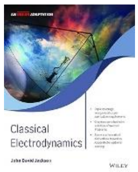


Name: Foundations of Electricity and Magnetism
Author: Basudev Gosh
Edition: 3rd Ed (2008)
Publisher: Books & Allied Ltd
ISBN: 978-8187134084

7.0 REFERENCE BOOKS AND MATERIALS



Name: Electricity and Magnetism
Author: Edward M. Purcell and David J. Morin
Edition: 3rd Ed.
Publisher: Cambridge University Press
ISBN: 978-1107014022



Name: Classical Electrodynamics
Author: John David Jackson
Edition: 2020
Publisher: Wiley
ISBN: 978-9388991070

8.0 MAPPING OF CLO TO PO AND PSO

The course outcomes and their mapping with program outcomes are specified in the table below

Course Learning Outcomes	Programme Outcomes (POs)												Programme Specific Outcome (PSOs)					
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6
CO1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

9.0 ASSESSMENT SCHEME

The evaluation system for this course consists of an 80% weightage on a comprehensive theory examination, which assesses students' understanding of various course topics, and a 20% weightage allocated to internal assessments, including internal examinations, assignments, class participation, and overall engagement in the course throughout the semester.

THEORY:

(A) Internal assessment: (20 marks): Continuous evaluation and internal assessment are implemented to foster and maintain a thorough understanding throughout the learning process. By regularly assessing comprehension through assignments, quizzes, and class participation, educators can address learning gaps promptly and support students in achieving deeper knowledge and proficiency in the subject matter.

(B) End-term examination (80 marks): The end-term examination serves as a culmination of students' learning in the course, assessing their comprehensive understanding and proficiency in various topics in the course. It provides a structured platform for students to demonstrate their knowledge, problem-solving abilities, and application of theoretical concepts, ultimately gauging their readiness to progress. Pattern of End term question paper

Section	Total Questions	Marks for each question	have to attempt	Total Marks
A	5	4	4	20
B	5	10	3	30
C	4	15	2	30

PRACTICUM:

(A) Internal assessment: (20 marks): In the internal assessment of the practicum components, the student's performance, understanding, skills, sincerity, and involvement in laboratory work during the entire semester are evaluated.

(B) End-term examination (80 marks): The ability to apply theoretical knowledge to real-world situations is the fundamental criterion used in the End Term examination. It typically involves students' activity on randomly assigned laboratory works and the Laboratory Report (Notebook) on the performed work in the entire semester. In the End examination, the student must complete randomly assigned tasks and prepare a report on their work, including appropriate conclusions. The mark distribution for the End term examination as follows.

Activity	Marks
Laboratory work in the Examination	40
Laboratory Notebook	20
Presentation/Viva-voce	30

PHY-001-CC-2230: THERMAL PHYSICS

NCrF Level:	5.0	
Programme:	Four Year Undergraduate Programme	**Semester:** Fourth
Course Category:	Major Course (Core Course)	
Credit (L: T: P)	3: 0: 1	
Credit Hours	Theory: 45 Hours, Practicum: 30 Hours	

1.0 COURSE LEARNING OBJECTIVES

The aim of this course is to provide a comprehensive idea on thermodynamic systems. The Course Learning Objectives are:

- comprehensive understanding of thermodynamic principles, including laws of thermodynamics, thermodynamic potentials, and equilibrium conditions.
- various modes of heat transfer such as conduction, convection, and radiation, and apply these principles to real-world scenarios.
- skills in statistical mechanics to describe the behavior of systems with many particles, including concepts of entropy, Boltzmann distribution, and partition functions.
- Explore phase transitions in materials, including the study of critical phenomena, phase diagrams, and the behavior of matter under different thermodynamic conditions.

2.0 COURSE LEARNING OUTCOME

After completing this course, students will be able to,

CO	Outcomes
CO1:	Learn the behaviour of gas molecules in terms of their motion and interactions to apply in explaining macroscopic properties such as volume, pressure, temperature and diffusion.
CO2:	Understand the kinetics of real gasses, including deviations from ideal behaviour, equations of state, critical phenomena analysis and experimental techniques.
CO3:	Learn techniques to analyze and solve problems related to gas behaviour using mathematical models derived from the kinetic theory in real work physical problems.
CO4:	Learn the principles of thermal equilibrium and temperature measurement through the Zeroth Law of Thermodynamics and its use in analysis of thermodynamic problems.
CO5:	Understand the concepts of energy conservation, internal energy, heat, and work on the basis of the first law of thermodynamics as well as to apply these in real work systems.
CO6:	Learn principles of entropy, irreversibility of natural processes as defined by the Second Law of Thermodynamics which enable them to study the energy transformation practical systems.
CO7:	Learn the formulations and interrelationships of thermodynamic potentials as well as to use in analyzing various processes in thermodynamic systems.
CO8:	Learn the derivation and physical significance of Maxwell's thermodynamic relations and to apply in solving problems involving change thermodynamic potentials
CO9:	Develop skills in conducting and analyzing experiments related to thermodynamic properties such as temperature, pressure, and volume.
CO10:	Gain experience in interpreting experimental data and documenting findings in structured lab reports with enhanced clarity while fostering teamwork in the laboratory work.

3.0 SKILLS TO BE LEARNED

- to solve complex thermodynamic problems using appropriate equations and methods.
- Apply thermodynamic principles to engines m refrigerators, and chemical reactions.
- Determine and analysis thermodynamic properties experimentally.

4.0 DETAILED CONTENTS OF THE COURSE: THEORY

Credit: 3 **Classroom Teaching: 45 Horus**

MODULE 1

Kinetic Theory of Gases: Maxwell-Boltzmann Law of Distribution of Velocities in an Ideal Gas and its Experimental Verification. Doppler Broadening of Spectral Lines and Stern's Experiment. Mean, RMS and Most Probable Speeds. Degrees of Freedom. Law of Equipartition of Energy (No proof required). Specific heats of Gases. **(3 Lectures)**

Molecular Collisions: Mean Free Path. Collision Probability. Estimates of Mean Free Path. Transport Phenomenon in Ideal Gases: (1) Viscosity, (2) Thermal Conductivity and (3) Diffusion. Brownian Motion and its Significance. **(4 Lectures)**

Real Gasses: Deviations from the Ideal Gas Equation. The Virial Equation. Andrew's Experiments on CO_2 Gas. Critical Constants. Continuity of Liquid and Gaseous State. Vapour and Gas. Boyle Temperature. Van der Waals Equation of State for Real Gases. Values of Critical Constants. Law of Corresponding States. Comparison with Experimental Curves. p-V Diagrams. Joule's Experiment. Free Adiabatic Expansion of a Perfect Gas. Joule-Thomson Porous Plug Experiment. Joule Thomson Effect for Real and Van der Waal Gases. Temperature of Inversion. Joule Thomson Cooling **[8 Lectures]**

MODULE 2

Zeroth and First Law of Thermodynamics: Extensive and intensive Thermodynamic Variables, Thermodynamic Equilibrium, Zeroth Law of Thermodynamics & Concept of Temperature, Concept of Work & Heat, State Functions, First Law of Thermodynamics and its differential form, Internal Energy, First Law & various processes, Applications of First Law: General Relation between C_P and C_V, Work Done during Isothermal and Adiabatic Processes, Compressibility and Expansion Coefficient. **[6 Lectures]**

Second Law of Thermodynamics: Reversible and Irreversible process with examples. Conversion of Work into Heat and Heat into Work. Heat Engines. Carnot's Cycle, Carnot engine & efficiency. Refrigerator & coefficient of performance, 2nd Law of Thermodynamics: Kelvin-Planck and Clausius Statements and their Equivalence. Carnot's Theorem. Applications of Second Law of Thermodynamics: Thermodynamic Scale of Temperature and its Equivalence to Perfect Gas Scale. **[6 Lectures]**

MODULE 3

Entropy: Concept of Entropy, Clausius Theorem. Clausius Inequality, Second Law of Thermodynamics in terms of Entropy. Entropy of a perfect gas. Principle of Increase of Entropy. Entropy Changes in Reversible and Irreversible processes with examples. Entropy of the Universe. Entropy Changes in Reversible and Irreversible Processes. Principle of Increase of Entropy. Temperature–Entropy diagrams for Carnot's Cycle. Third Law of Thermodynamics. Unattainability of Absolute Zero [**4 Lectures]**

Thermodynamic Potentials: Extensive and Intensive Thermodynamic Variables. Thermodynamic Potentials: Internal Energy, Enthalpy, Helmholtz Free Energy, Gibbs Free Energy. Their Definitions, Properties and Applications. Surface Films and Variation of Surface Tension with Temperature. Magnetic Work, Cooling due to adiabatic demagnetization, First and second order Phase Transitions with examples, Clausius Clapeyron Equation and Ehrenfest equations [**5 Lectures]**

Derivations and applications of Maxwell's Relations: Maxwell's Relations:(1) Clausius Clapeyron equation, (2) Values of Cp-Cv, 21 (3) Tds Equations, (4) Joule-Kelvin coefficient for Ideal and Van der Waal Gases, (5) Energy equations, (6) Change of Temperature during Adiabatic Process. **[6 Lectures]**

5.0 DETAILED CONTENTS OF THE COURSE: PRACTICUM

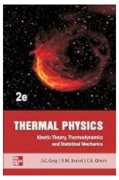
Credit: 2 **Laboratory Work: 30 Hours**

In practicum, students perform a variety of experiments designed to illustrate and reinforce theoretical concepts of heat and thermodynamics. Students are required to conduct experiments from the provided list, meticulously following the suggested procedures and protocols outlined for each. Subsequently, they must compile comprehensive reports for every experiment, adhering to scientific standards and conventions. These reports should encompass a detailed description of the experimental setup and methodology employed, including any modifications made during the course of the experiment. Furthermore, students are expected to record and analyze their experimental data systematically, drawing upon relevant theoretical concepts and principles to interpret their findings accurately. Additionally, the reports should include a thorough discussion of the results obtained, highlighting any observed trends, anomalies, or correlations, and offering insightful explanations or hypotheses where applicable. Moreover, students must demonstrate proficiency in presenting their results graphically, utilizing tables, figures, and diagrams to enhance clarity and facilitate comprehension. Finally, each report should conclude with a succinct summary of the key findings and conclusions drawn from the experiment, along with any recommendations for further investigation or improvement.

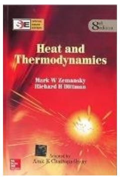
The teacher has the flexibility to introduce a wide range of laboratory experiments that directly correlate with and reinforce the theoretical concepts covered in the course curriculum. These experiments serve as practical applications of the theoretical principles discussed in lectures.

1. To determine the pressure coefficient of air by constant volume air thermometer.
2. To determine the melting point of a substance with a constant volume air thermometer.
3. To determine the specific heat of a liquid by the method of cooling
4. To determine the specific heat of copper-by-copper block calorimeter
5. To determine the coefficient of thermal conductivity of copper by Searle's apparatus.
6. To determine the coefficient of thermal conductivity of a rubber tubing.
7. To determine the coefficient of thermal conductivity of a glass in the form of a tube.
8. To determine the conductivity of glass by the method of Lees and Chorlton.
9. To determine the value of Searle's Fraction Cone method.
10. To determine the mechanical equivalent of heat with Callender and Barnes Continuous flow calorimeter.
11. To determine the temperature coefficient of resistance for platinum by means of Carey Foster's bridge.
12. To determine the temperature coefficient of resistance of platinum by means Callender and Griffth's Bridge.
13. To determine the value of Stefan's Constant.
14. To determine Mechanical Equivalent of Heat, J, by Callender and Barnes constant flow method.
15. To determine the Coefficient of Thermal Conductivity of Cu by Searle's Apparatus.
16. To determine the Coefficient of Thermal Conductivity of Cu by Angstrom's Method.
17. To determine the Coefficient of Thermal Conductivity of a bad conductor by Lee and Charlton's disc method.
18. To determine the Temperature Coefficient of Resistance by Platinum Resistance Thermometer (PRT).
19. To study the variation of Thermo-Emf of a Thermocouple with Difference of Temperature of its Two Junctions.
20. To calibrate a thermocouple to measure temperature in a specified Range using Null Method as well as Direct measurement and to determine Neutral Temperature.

6.0 TEXT BOOKS

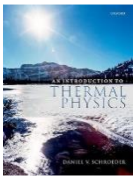


Name: Thermal Physics: with Kinetic Theory, Thermodynamics and Statistical Mechanic
Author: S.C. Garg, R.M. Bansal and C.K. Ghosh
Edition: 2^{nd} Ed.
Publisher: McGraw Hill Education
ISBN: 978-1259003356

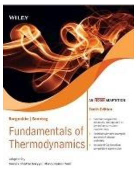


Name: Heat and Thermodynamics
Author: Mark Zemansky and Richard Dittman
Edition: 8^{th} Ed
Publisher: McGraw Hill Education
ISBN: 978-0070700352

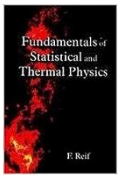
7.0 REFERENCE BOOKS AND MATERIALS



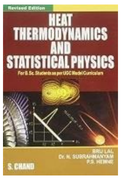
Name: An Introduction to Thermal Physics
Author: Daniel V. Schroeder
Edition: 2021
Publisher: Oxford
ISBN: 978-0192895547



Name: Fundamentals of Thermodynamics
Author: Claus Borgnakke ; Richard E. Sonntag; Souvik Bhattacharyya; Manoj Kumar Soni
Edition:10^{th} Ed.
Publisher: Wiley
ISBN: 978-9354642210



Name: Fundamentals of Statistical and Thermal Physics
Author: E Reif
Edition:
Publisher: Sarat Book House
ISBN: 978-9380663142



Name: Heat Thermodynamics & Statistical Physics
Author: Brijlal and Subrahmanyam
Edition: 2017
Publisher: S.Chand
ISBN: 978-8121928137

6.0 0 MAPPING OF CLO TO PO AND PSO

The course outcomes and their mapping with program outcomes are specified in the table below

Course Learning Outcomes	Programme Outcomes (POs)												Programme Specific Outcome (PSOs)					
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6
CO1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

9.0 ASSESSMENT SCHEME

The evaluation system for this course consists of an 80% weightage on a comprehensive theory examination, which assesses students' understanding of various course topics, and a 20% weightage allocated to internal assessments, including internal examinations, assignments, class participation, and overall engagement in the course throughout the semester.

THEORY:

(A) Internal assessment: (20 marks): Continuous evaluation and internal assessment are implemented to foster and maintain a thorough understanding throughout the learning process. By regularly assessing comprehension through assignments, quizzes, and class participation, educators can address learning gaps promptly and support students in achieving deeper knowledge and proficiency in the subject matter.

(B) End-term examination (80 marks): The end-term examination serves as a culmination of students' learning in the course, assessing their comprehensive understanding and proficiency in various topics in the course. It provides a structured platform for students to demonstrate their knowledge, problem-solving abilities, and application of theoretical concepts, ultimately gauging their readiness to progress. Pattern of End term question paper

Section	Total Questions	Marks for each question	have to attempt	Total Marks
A	5	4	4	20
B	5	10	3	30
C	4	15	2	30

PRACTICUM:

(A) Internal assessment: (20 marks): In the internal assessment of the practicum components, the student's performance, understanding, skills, sincerity, and involvement in laboratory work during the entire semester are evaluated.

(B) End-term examination (80 marks): The ability to apply theoretical knowledge to real-world situations is the fundamental criterion used in the End Term examination. It typically involves students' activity on randomly assigned laboratory works and the Laboratory Report (Notebook) on the performed work in the entire semester. In the End examination, the student must complete randomly assigned tasks and prepare a report on their work, including appropriate conclusions. The mark distribution for the End term examination as follows.

Activity	Marks
Laboratory work in the Examination	40
Laboratory Notebook	20
Presentation/Viva-voce	20

PHY-001-CC-2240: ELECTRONICS - I

NCrF Level:	5.0
Programme:	Four Year Undergraduate Programme — **Semester:** Fourth
Course Category:	Major Course (Core Course)
Credit (L: T: P)	3: 0: 2
Credit Hours	Theory: 45 Hours, Practicum: 60 Hours

1.0 COURSE LEARNING OBJECTIVES

This course aims to provide a comprehensive understanding of network theory, semiconductor devices, amplifiers, and oscillators. The Learning Objectives of the course are:

- Analyze and solve complex AC and DC electrical circuits using network theorems and techniques.
- Understanding the characteristics, operation, and applications of diodes and transistors.
- Understand the design, analysis, and practical implementation of amplifiers and oscillators,
- Analyze and apply principles of electronic communication systems,
- utilizing electronic laboratory equipment, conducting experiments, troubleshooting circuits

2.0 COURSE LEARNING OUTCOME

At the end of the course, the student is expected to assimilate knowledge of the following

CO	Outcomes
CO1:	Develop a strong understanding of both theoretical principles and practical implementations in network theory in different types of electronic circuits
CO2:	Learn to analyze and solve complex electrical circuits using various techniques and theorems, and will be proficient in designing and evaluating circuits for diverse applications.
CO3:	Understand the operating principles and characteristics of semiconductor diodes, and will be able to analyze and design basic diode circuits for various practical applications.
CO4:	Understand the unique characteristics Zener diodes, Schottky diodes, and light-emitting diodes (LEDs), tunnel diodes and be able to design and utilize them in specific applications.
CO5:	Understand the fundamental principles and operating modes of transistors (BJTs) and able to analyze, design, and implement circuits for amplification and switching applications,
CO6:	Understand the operation of various transistor amplifier configurations which enable them in analyzing, designing and optimizing transition amplifiers for different applications.
CO7:	understand the fundamental principles, stability criteria of oscillators circuits along with the working of different types of practical oscillators and their applications.
CO8:	Learn the basics of Analog communication systems, techniques of signal transmission, reception, and the impact of noise on system performance.
CO9:	Gain hands-on experience in building and testing electronic circuits using different instruments and develop technical competence to troubleshoot electronic circuits.
CO10:	Able to prepare clear, structured, and concise scientific reports, effectively presenting laboratory works and findings with enhanced clarity.

3.0 SKILLS TO BE LEARNED

- To analyze behavior of electronic circuits and troubleshoot faults in these circuits.
- Design, develop and build analog circuits such as amplifiers, oscillators, and filters.
- Use of different electronic measuring instrument to measure various electronic parameters.
- diagnosing and fixing issues in electronic circuits using tools like oscilloscopes and multimeters.

4.0 DETAILED CONTENTS OF THE COURSE: THEORY

Credit: 3 **Classroom Teaching: 45 Horus**

MODULE 1

Elements of Network Theory: Network elements - active and passive, linear and nonlinear, bilateral and unilateral, voltage source and current source (ideal and real). Conversion of Voltage source to current source, Voltage divider and current divider theorem. Series and parallel combination of resistor, capacitor and inductor, branch, loop and nodal analysis techniques, Star and Delta conversion **[7 Hours]**

Network Theorems: Principal of duality, Superposition theorem, Thevenin theorem, Norton theorem. Their applications in DC and AC circuits with more than one source, Thevenin's and Norton's equivalent circuits – applications. Maximum Power Transfer theorem– impedance matching, Reciprocity Theorem, Millman's Theorem, Tellegen's theorem. **[8 Hours]**

MODULE 2

Semiconductor Diode: Conductivity and Mobility in semiconductor, Concept of Drift velocity. Barrier formation in PN Junction Diode. Current Flow Mechanism, Static and Dynamic Resistance, Diode as Rectifier: Half-wave, full wave Rectifiers, Ripple Factor and Rectification Efficiency, C-filter, Zener Diode and Voltage Regulation, Clipper and Clamper circuits, **[6 Hours]**

Special Diode: working principle of varactor diode, Tunnel diode, light emitting diode, gun diode and their applications. Photodiode as detector and power source - Solar cell. **[3 Hours]**

Three Terminal Devices: Bipolar junction transistor (BJT) - **n**-p-n and p-n-p, Characteristics of CB, CE and CC Configurations. Current gains α and β Relations between α and β. Load Line analysis of Transistors. DC Load line and Q-point. Physical Mechanism of Current Flow. Active, Cut off and Saturation Regions. basic transistor amplifier, Transistor Biasing and Stabilization Circuits. Field Effect Transistor – JFET and MoSFET and their applications. **[6 Hours]**

MODULE 3

Transistor Amplifier: Transistor as 2-port Network – Z,Y and h parameter, h-parameter Equivalent Circuit. Analysis of a single-stage CE amplifier using Hybrid Model- Input and Output Impedance. Current, Voltage and Power Gains. Classification of Class A, B & C Amplifiers. Coupled Amplifier**:** Two stage RC-coupled amplifier and its frequency response. **[7 Hours]**

Oscillators: Effects of Positive and Negative Feedback in amplifiers - Input Impedance, Output Impedance, Gain, Stability, Distortion and Noise, Barkhuizen Criterion for self-sustained oscillations. RC Phase shift oscillator, determination of Frequency. Hartley & Colpitts oscillators. Multivibrator **[6 Hours]**

Electronic Communications: Analog communication systems, Amplitude modulation (AM): principles, generation, and detection, Frequency modulation (FM) and phase modulation (PM), AM and FM transmitters and receivers Signal-to-noise ratio (SNR), bandwidth, and efficiency. **[2 Hours]**

5.0 DETAILED CONTENTS OF THE COURSE: PRACTICUM

Credit: 2 **Laboratory Work: 60 Hours**

In the practicum component of the course, students will undergo hands-on experience with electronic components and measuring instruments. covers the identification and testing of basic components, circuit analysis, and practical applications of diodes and transistors. Through a series of practical exercises, students will learn designing and troubleshooting of electronic circuits.

Students are required to conduct experiments from the provided list, meticulously following the suggested procedures and protocols outlined for each. Subsequently, they must compile comprehensive reports for every experiment, adhering to scientific standards and conventions. These reports should encompass a detailed description of the experimental setup and methodology employed, including any modifications made during the course of the experiment. Furthermore, students are expected to record and analyze their experimental data systematically, drawing upon relevant theoretical concepts and principles to interpret their findings accurately. Additionally, the reports should include a thorough discussion of the results obtained, highlighting any observed trends, anomalies, or correlations, and offering insightful explanations or hypotheses where applicable. Moreover, students must demonstrate proficiency in presenting their results graphically, utilizing tables, figures, and diagrams to enhance clarity and facilitate comprehension. Finally, each report should conclude with a succinct summary of the key findings and conclusions drawn from the experiment, along with any recommendations for further investigation or improvement.

The teacher has the flexibility to introduce a wide range of laboratory experiments that directly correlate with and reinforce the theoretical concepts covered in the course curriculum. These experiments serve as practical applications of the theoretical principles discussed in lectures.

Suggested List of Experiments:

Network Theory:

1. Verify voltage divider theorem and current divider theorem with four resistances
2. Determine Thevenin and Norton equivalent circuits and validate the circuits with experimental measurements.
3. Verify superposition principle in an electronic circuit with a multi-source.
4. Verify Thevenin's Theorem and Norton's Theorem in electronic circuits.
5. Verify Maximum Power Transfer Theorem at the output of an electronic circuit.
6. Verify Reciprocity Theorem and Tellegen's Theorem in an electronic circuit
7. To Study of AC bridges – (i) Maxwell`s Capacitance Bridge (b) De Sauty's Bridge (c)Schering Bridge (d) Owen`s Bridge (e) Anderson's Bridge (f) Maxwell`s Inductance Bridge (g) Kelvin`s Bridge
8. To Study of RC circuit to verify $X_c = 1/c\omega$ and LC circuit to verify $X_L = L\omega$
9. Study of Z, Y and h parameter of a passive two port network

Semiconductor diode

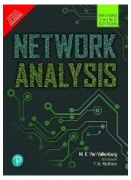
1. To draw the characteristic of a silicon diode and a germanium diode under forward bias condition and find cut-in voltage, reverse saturation current, static and dynamic resistances
2. To draw the characteristic of a Silicon diode and find the cut-in voltage, reverse Saturation current and static & dynamic resistances at five different temperatures.
3. To draw the characteristics of two different Zener diodes & calculate cut-in voltage, reverse Saturation current, break down voltage.

4. To compare the Ripple Factor, Efficiency, Peak Factor and regulation characteristics of half wave rectifier, full wave rectifier and Bridge rectifier.
5. To study the Ripple and Regulation characteristics of full wave rectifiers with and without filter circuits of different types.
6. To draw and analysis the characteristics of a Light dependent resistor and a photodiode for five different light illumination conditions
7. To draw characteristics & power curves of solar cells under different light illumination conditions and determine the maximum power point & efficiency for each case.
8. To determine the Junction capacitance of a PN Junction diode and Schottky Diode
9. To determine the value of Planck's constant using a photoelectric cell and Light emitting diode.

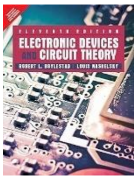
Transistor:

1. To draw the static input and output characteristics curves of a transistor in CE configuration and determine its 'h' parameters
2. To draw the static input and output characteristics curves of a transistor in CB configuration and determine its 'h' parameters
3. To study the various biasing configurations of BJT for normal class A operation.
4. To design a CE transistor amplifier of a given gain (mid-gain) using voltage divider bias.
5. To Determine the band gap by measuring the resistance of a thermistor as a function of temperature.
6. Study of the Common Emitter Amplifier/Common Collector/Common Base and for evaluation of Operating Point, Voltage Gain, Input and Output Impedance, Current Gain of the Amplifier.
7. To study an emitter follower circuit and (a) plot the frequency response curve (b) measure the voltage, gain and current gain (c) find the input and output impedance of the circuit.
8. To study and Measure the Frequency Response of FET Amplifier and measure the Various Parameters of FET Amplifier.
9. To design a phase shift oscillator of given specifications using BJT
10. To study the frequency response of voltage, gain of an RC-coupled transistor amplifier.
11. To design a Wien bridge oscillator for a given frequency using an op-amp.
12. To study the Colpitts oscillator
13. To design a circuit to simulate the solution of a $1^{st}/2^{nd}$ order differential equation.
14. To construct and study a small signal common emitter R-C coupled transistor amplifier and (a) plot the frequency response curve (b) find the midband voltage gain, input impedance and output impedance.
15. Study of Wien Bridge oscillator and effect on Output frequency with variation in RC combination.
16. Study of Phase Shift oscillator and effect on Output frequency with variation in RC combination
17. Study of Colpitt Oscillator and effect on Output frequency with variation in LC combination.
18. Study of Hartley Oscillator and effect on Output frequency with variation in RC combination.
19. Study of Clapp Oscillator and effect on Output frequency with variation in RC combination.

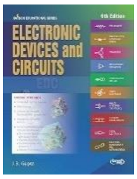
6.0 TEXT BOOKS



Name: Network Analysis
Author: M. E. Van Valkenburg and T.S. Rathore
Edition: 3^{rd}
Publisher: Pearson Education
ISBN: 978-9353433123

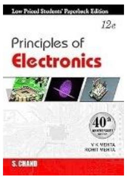


Name: Electronic Devices and Circuit Theory
Author: Robert L. Boylestad and Louis Nashelsky
Edition: 11th Ed.
Publisher: Pearson Education India
ISBN: 978-9332542600

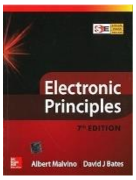


Name: Electronic Devices and Circuits
Author: A. B. Gupta
Edition: 2013
Publisher: S.K. Kataria & Sons
ISBN: 978-9350143148

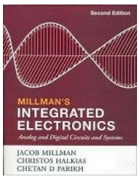
7.0 REFERENCE BOOKS AND MATERIALS



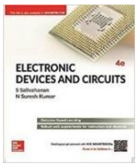
Name: Principles of Electronics
Author: V.K. Mehta and Rohit Mehta
Edition: 12th Ed.
Publisher: S. Chand Publishing
ISBN: 978-9352838363



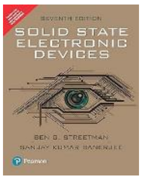
Name: Electronic Principles
Author:
Edition:
Publisher:
ISBN:



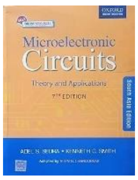
Name: Integrated Electronic
Author: Jacob Millman, Christos Halkias, Chetan Parikh
Edition: 2nd Ed (2017)
Publisher: McGraw Hill Education
ISBN: 978-0070151420



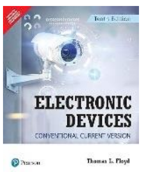
Name: Electronic Devices and Circuits
Author: S. Salivahanan and N. Suresh Kumar
Edition: 4th Ed.
Publisher: McGraw Hill Education
ISBN: 978-9339219505



Name: Solid State Electronic Devices
Author: B.G.Streetman & S.K.Banerjee
Edition: 6th Ed.
Publisher: Pearson
ISBN: 978-9332555082



Name: Microelectronic circuits
Author: , A.S. Sedra, K.C. Smith, A.N. Chandorkar
Edition: 7th Ed.
Publisher: Oxford University Press
ISBN: 9780199476299



Name: Electronic Devices,
Author: Thomas L. Floyd
Edition: 10th Ed.
Publisher: Pearson India.
ISBN: 978-9354493935

6. 6.0 0 MAPPING OF CLO TO PO AND PSO

The course outcomes and their mapping with program outcomes are specified in the table below

Course Learning Outcomes	Programme Outcomes (POs)												Programme Specific Outcome (PSOs)					
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6
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CO2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

9.0 ASSESSMENT SCHEME

The evaluation system for this course consists of an 80% weightage on a comprehensive theory examination, which assesses students' understanding of various course topics, and a 20% weightage allocated to internal assessments, including internal examinations, assignments, class participation, and overall engagement in the course throughout the semester.

THEORY:

(A) Internal assessment: (20 marks): Continuous evaluation and internal assessment are implemented to foster and maintain a thorough understanding throughout the learning process. By regularly assessing comprehension through assignments, quizzes, and class participation, educators can address learning gaps promptly and support students in achieving deeper knowledge and proficiency in the subject matter.

(B) End-term examination (80 marks): The end-term examination serves as a culmination of students' learning in the course, assessing their comprehensive understanding and proficiency in various topics in the course. It provides a structured platform for students to demonstrate their knowledge, problem-solving abilities, and application of theoretical concepts, ultimately gauging their readiness to progress.
Pattern of End term question paper

Section	Total Questions	Marks for each question	have to attempt	Total Marks
A	5	4	4	20
B	5	10	3	30
C	4	15	2	30

PRACTICUM:

(A) Internal assessment: (20 marks): In the internal assessment of the practicum components, the student's performance, understanding, skills, sincerity, and involvement in laboratory work during the entire semester are evaluated.

(B) End-term examination (80 marks): The ability to apply theoretical knowledge to real-world situations is the fundamental criterion used in the End Term examination. It typically involves students' activity on randomly assigned laboratory works and the Laboratory Report (Notebook) on the performed work in the entire semester. In the End examination, the student must complete randomly assigned tasks and prepare a report on their work, including appropriate conclusions. The mark distribution for the End term examination as follows.

Activity	Marks
Laboratory work in the Examination	40
Laboratory Notebook	20
Presentation/Viva-voce	30

PHY-001-CC-3110: MATHEMATICAL PHYSICS - III

NCrF Level: 6.0

Programme: Four Year Undergraduate Programme **Semester:** Fifth

Course Category: Major Course (Core Course)

Credit (L: T: P) 3: 0: 1

Credit Hours Theory: 45 Hours, Practicum: 30 Hours

1.0 COURSE LEARNING OBJECTIVES

This course is to provide a basic understanding on Complex variables, Group Theory, Probability Theory and Tensors as well as their applications. The Learning Objectives of the course are:

- To furnish the ability of analyzing and solving problems involving complex functions, including their integration, differentiation, and their applications
- To enlighten about the basics of concepts behind the groups including various types of special groups and their applications.
- To understand and apply fundamental concepts of probability, analyze random variables and their distributions and key theorems in the real-world problems.
- To understand and apply the fundamental concepts of tensor algebra and calculus, including tensor operations, transformations, and applications
- knowledge and computational skills in numerical analysis to solve mathematical problems using various techniques.

2.0 COURSE LEARNING OUTCOME

After completing this course, students will be able to,

CO	Outcomes
CO1:	Understand and apply complex functions, perform complex integration and series expansions, utilize conformal mapping, compute residues, and solve various problems in Physics.
CO2:	able to understand fundamental and use of group theory including group structures, subgroups, homomorphisms, normal subgroups, quotient groups, and symmetry groups.
CO3:	Develop the skills to model, analyze, and interpret random phenomena using probabilistic concepts and tools, including probability distributions, expectation, and variance
CO4:	Acquire the ability to understand, manipulate, and apply tensor algebra and calculus in various scientific and engineering contexts, including mechanics, relativity, and data analysis.
CO5:	Develop the ability to solve mathematical problems involving roots, systems of linear equations, interpolation, differentiation, integration, and differential equations.
CO6:	Gain proficiency in designing and coding numerical algorithms using programming languages or software tools Python.
CO7:	Get the skill to choose appropriate techniques to model and solve real-world problems of Physics and engineering.
CO8:	Able to prepare clear, structured, and concise scientific reports, effectively presenting laboratory works and findings with enhanced clarity.

3.0 SKILLS TO BE LEARNED

- To Evaluate integration of a function using complex variables
- To analyze data sent using the concepts of probability.
- To solve complex mathematical problems using various numerical techniques

4.0 DETAILED CONTENTS OF THE COURSE: THEORY

Credit: 3 **Classroom Teaching: 45 Horus**

MODULE 1

Complex Analysis: Complex Numbers and their Graphical Representation. Euler's formula, De Moivre's theorem, Roots of Complex Numbers. Complex functions, analytic functions. Functions of Complex Variables. Analyticity and Cauchy-Riemann Conditions. Examples of analytic functions. Singular functions: poles and branch points, order of singularity, branch cuts. Integration of a function of a complex variable. Cauchy's Inequality. Cauchy's Integral formula. Simply and multiply connected regions. Laurent and Taylor's expansion. Residues and Residue Theorem. Application in solving Definite Integrals. **[15 hours]**

MODULE 2

Group Theory: Review of sets, Mapping and Binary Operations. Groups: Elementary properties of groups, uniqueness of solution, Subgroup, Centre of a group, Cosets of a subgroup, cyclic group, Permutation/Transformation. Homomorphism and Isomorphism of groups. Normal and conjugate subgroups. Completeness and Kernel. Some special groups: SO(2), SO(3), SU(2), SU(3). **[15 hours]**

MODULE 3

Probability Theory: Fundamental Probability Theorems. Conditional Probability, Bayes' Theorem, Repeated Trials, Binomial and Multinomial expansions. Random Variables and probability distributions, Discrete and continuous random variables, Expectation and Variance, Probability distribution functions: Binomial, Poisson and Gaussian (or Normal) distributions, Mean and variance of these distributions. **[9 hours]**

Fundamental of Tensors: Transformation of Coordinates. Einstein's Summation Convention. Relation between Direction Cosines. Tensors. Algebra of Tensors. Sum, Difference and Product of Two Tensors. Contraction. Quotient Law of Tensors. Symmetric and Antisymmetric Tensors. Invariant Tensors: Kronecker delta. **[6 hours]**

5.0 DETAILED CONTENTS OF THE COURSE: PRACTICUM

Credit: 1 **Laboratory Work: 30 Hours**

In the practicum component of the course student learn to use of python libraries like NumPy, SciPy, Matplotlib for numerical computation and solving problem of physics. They have to go solve problems related to the topics mentioned below.

(a) **Root Finding Methods:** Bisection method, Scant Method, Newton-Rapson method.

(b) **Solution of Linear system of equations:** Gauss elimination method and Gauss Seidel method

(c) **Numerical Integration:** Trapezoidal rule, Simpson's rule, Monte Carlo Integration

(d) **Numerical differentiation:** Forward, backward, and central differences, higher order derivatives

(e) **Solving Ordinary Differential Equations:** Euler's method, Runge-Kutta methods.

(f) **Interpolation and Curve Fitting:** Polynomial interpolation. Spline interpolation, Least squares fitting.

(g) **Linear Algebra:** Solving linear systems of equations, Matrix factorizations, eigen value and eigen function.

(h) **Solutions of Partial Differential Equations:** Finite difference method, Boundary value problems.

(i) **Fast Fourier Transform (FFT):** Applications in signal processing.

(j) **Statistical Methods:** Probability distributions, Hypothesis testing and confidence intervals.

Exercise:

(A) **Solution of Linear system of equations**: by Gauss elimination method and Gauss Seidal method.

(B) **Numerical Integration:** Newton Cotes Integration methods (Trapezoidal and Simpson rules) for definite integrals: Given acceleration with equidistant time data calculate position and velocity and plot them. Application to other mathematical and physical problems.

(C) **System of First order Differential Equations**: (Forth Order RK method)

- Solve the coupled differential equations

$$\frac{dx}{dt} = y + x - \frac{x^3}{3}\,; \frac{dy}{dt} = -x$$

for four initial conditions: $x(0) = 0, y(0) = -1, -2, -3, -4$

Plot $x\ vs\ y$ for each of the four initial conditions

- Solve the first order differential equation like
  a) Radioactive decay
  b) Current in RC, LC circuits with DC source
  c) Newton’s law of cooling

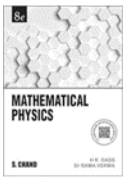
(D) **Second-order differential equation (Euler and RK Methods):**

- Solve the differential equation of second order
  a) Classical equations of motion Second order Differential Equation
  b) Harmonic oscillator (no friction)
  c) Damped Harmonic oscillator
  d) Over damped Harmonic oscillator
  e) Critical damped Harmonic oscillator
  f) Oscillatory Harmonic oscillator
  g) Forced Harmonic oscillator
  h) Transient and Steady state solution

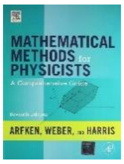
(E) **Partial Differential equation:**

- Find the solution of
  a) Wave equation
  b) Heat equation
  c) Poisson equation
  d) Laplace equation

6.0 TEXT BOOKS

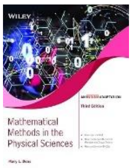


Name: Mathematical Physics
Author: H.K. Dass and R. Verma
Edition: 8th Ed. (2022)
Publisher: S. Chand & Company.
ISBN: 978-9352837229

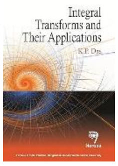


Name: Mathematical Methods for Physicists,
Author: G.B. Arfken, H.J. Weber, F.E. Harris
Edition: 7th Edn
Publisher: Elsevier
ISBN: 978-9381269558

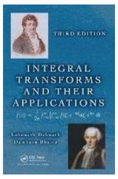
7.0 REFERENCE BOOKS AND MATERIALS



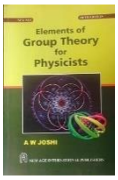
Name: Mathematical Methods in the Physical Sciences
Author: M. L. Boas, A.P.Singh, K. Mondal, M.S. Anand
Edition: 3rd Ed.
Publisher: Wiley
ISBN: 978-9354644252



Name: Integral Transforms and Their Applications
Author: K P Das
Edition: 2019
Publisher: Narosa Publishing House
ISBN: 978-8184876819



Name: Integral Transforms and Their Applications
Author: Lokenath Debnath and Dambaru Bhatta
Edition: 3rd Ed.
Publisher: Chapman and Hall/CRC
ISBN: 978-1482223576



Name: Elements Of Group Theory for Physicists
Author: A W Joshi
Edition: 5th Ed.
Publisher: New Age International Publishers
ISBN: 978-9386070944

6.0 MAPPING OF CLO TO PO AND PSO

The course outcomes and their mapping with program outcomes are specified in the table below

Course Learning Outcomes	Programme Outcomes (POs)												Programme Specific Outcome (PSOs)					
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6
CO1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

9.0 ASSESSMENT SCHEME

The evaluation system for this course consists of an 80% weightage on a comprehensive theory examination, which assesses students' understanding of various course topics, and a 20% weightage allocated to internal assessments, including internal examinations, assignments, class participation, and overall engagement in the course throughout the semester.

THEORY:

(A) Internal assessment: (20 marks): Continuous evaluation and internal assessment are implemented to foster and maintain a thorough understanding throughout the learning process. By regularly assessing comprehension through assignments, quizzes, and class participation, educators can address learning gaps promptly and support students in achieving deeper knowledge and proficiency in the subject matter.

(B) End-term examination (80 marks): The end-term examination serves as a culmination of students' learning in the course, assessing their comprehensive understanding and proficiency in various topics in the course. It provides a structured platform for students to demonstrate their knowledge, problem-solving abilities, and application of theoretical concepts, ultimately gauging their readiness to progress. Pattern of End term question paper

Section	Total Questions	Marks for each question	have to attempt	Total Marks
A	5	4	4	20
B	5	10	3	30
C	4	15	2	30

PRACTICUM:

(A) Internal assessment: (20 marks): In the internal assessment of the practicum components, the student's performance, understanding, skills, sincerity, and involvement in laboratory work during the entire semester are evaluated.

(B) End-term examination (80 marks): The ability to apply theoretical knowledge to real-world situations is the fundamental criterion used in the End Term examination. It typically involves students' activity on randomly assigned laboratory works and the Laboratory Report (Notebook) on the performed work in the entire semester. In the End examination, the student must complete randomly assigned tasks and prepare a report on their work, including appropriate conclusions. The mark distribution for the End term examination as follows.

Activity	Marks
Laboratory work in the Examination	40
Laboratory Notebook	20
Presentation/Viva-voce	20

PHY-001-CC-3120: CLASSICAL MECHANICS

NCrF Level:	5.5		
Programme:	Four Year Undergraduate Programme	**Semester:**	Fifth
Course Category:	Major Course (Core Course)		
Credit (L: T: P)	3: 1: 0		
Credit Hours	Theory: 45 Hours, Tutorial: 15 Hours		

1.0 COURSE LEARNING OBJECTIVES

The emphasis of the course is on enhancing the problem-solving ability of the students in the field of Mechanics using the Lagrangian and Hamiltonian approach. The learning objectives of the course are:

- Enhance the concepts of kinematics and dynamics to analyze the trajectory, acceleration, and forces acting on objects.
- Enhance knowledge of conservation of energy and momentum, and apply them to solve problems involving collisions, oscillations, and systems of particles.
- Explore rotational dynamics, including the analysis of angular momentum, torque, and rotational kinematics, and apply these principles to rotating bodies and systems.
- Provide knowledge on principles and applications of the Special Theory of Relativity, including time dilation, length contraction, and the equivalence of mass and energy.

2.0 COURSE LEARNING OUTCOME

After completing this course, students will be able to,

CO	Outcomes
CO1:	Understand the principles of Lagrangian and its significance in describing the dynamical systems, and to constitute and solve equations of motion for various real-world systems.
CO2:	Learn to apply variational principles to analyze physical systems and derive equations of motion using the Hamiltonian formalism.
CO3:	Understand the mathematical framework of canonical transformations to simplify a complex dynamical system and to derive transformed Hamiltonian equations.
CO4:	Learn the mathematical formalism of Hamilton-Jacobi theory and to elucidate the dynamics and motion of conservative systems.
CO5:	Understand and apply the principles of central force motion, conservation laws and orbital dynamics to analyze and solve problems related to particle motion under central forces.".
CO6:	Analyze and predict the motion of rigid bodies by applying principles of kinematics, dynamics, and energy conservation to solve problems involving rotation and translation.
CO7:	Understand the principles of linearized dynamics and small oscillations and to analyze the behaviour of such systems near equilibrium points in mechanical and physical systems
CO8:	Understand the foundational principles of special relativity and to apply transformation equations in analyzing various relativistic phenomena and kinematics.

3.0 SKILLS TO BE LEARNED

- To solve problems of various dynamical systems
- To analysis motion of object moving with a speed nearer to velocity of light

4.0 DETAILED CONTENTS OF THE COURSE: THEORY

Credit: 3+1 **Classroom Teaching: 45+15 Hours**

MODULE 1

Lagrangian Dynamics and Hamiltonian formulation: Generalized coordinates, Constraints, Principle of Virtual Work, D'Alembert's principle and its applications, Lagrange's equation and its applications. Jacobi integral and energy conservation, Concept of symmetry, velocity dependent potential. Variational calculus and Least Action principle, Hamilton's principle, Lagrange's equation from Hamilton's principle, Legendre transformations, Hamilton's function and Hamilton's equation, configuration space, phase space and state space, Hamilton's equations from Variational principle**. [8+3 hours]**

Canonical transformations and Hamilton Jacobi Theory: Generating function, canonical transformation and its examples, group property, Lagrange and Poisson brackets and other canonical invariants, equation of motions, Infinitesimal canonical theorem in Poisson bracket formalism, Jacobi identity, Angular momentum Poisson bracket relations. The Hamilton-Jacobi equation for Hamilton's principle and characteristic functions with example; the harmonic oscillator, Separation of variable in Hamilton-Jacobi equation; Action-angle variables and its examples – the Kepler problem in Action-angle variables. **[7+2 hours]**

MODULE 2

Central Force Motion: Reduction of two body problem to one-body problem, general properties of central force, effective potential, motion in a central force field – general solution, inverse square law force. Kepler's laws and laws of gravitation, orbits of artificial satellites, satellite parameters, Virial theorem, scattering in a central force field and in laboratory coordinates **[7+2 hours]**

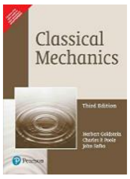
Rigid Bodies: Kinematics of rigid body, orthogonal transformations, Euler's theorem and its applications, finite and infinitesimal rotations, rate of change of a vector, the rigid body equation of motion, Coriolis effect, angular momentum and kinetic energy of motion about a point, the inertia tensor and the moment of inertia, the principal axis transformation, Euler equations of motion. **[8+3 hours]**

MODULE 3

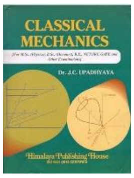
Small Amplitude Oscillations: Lagrange's equations of motion for small oscillations, eigenvalue equation and normal coordinates and frequencies for systems with many degrees of freedom, problems for small oscillations-parallel, double, linear triatomic molecule and vibration strings. Minima of potential energy and points of stable equilibrium, Linear and nonlinear waves, Solitary Waves, KdV equation, Solitons. **[10+3 hours]**

Special Theory of Relativity: Special theory of relativity and its postulates, Galilean transformations, Lorentz transformations relativistic kinematics (Relativity of Mass, Length, Time), twin paradox, The invariant interval, light cone and world lines. Space- time diagrams, Minkowski Space, Lorentz Tensor, Addition of velocities, Mass-Energy relation, Force in relativistic mechanics, Relativistic Doppler's Effect **[5+2 hours]**

6.0 TEXT BOOKS

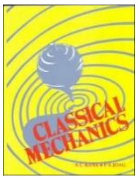


Name: Classical Mechanics
Author: H.Goldstein, C.P. Poole, J.L. Safko
Edition: 3rd **Ed.**
Publisher: Pearson Education.
ISBN: 978-8131758915

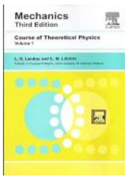


Name: Classical Mechanics
Author: J. C. Upadhyaya
Edition: 3rd Ed.
Publisher: Himalaya Publishing House
ISBN: 9789353675356,

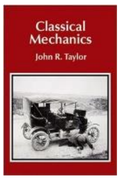
7.0 REFERENCE BOOKS AND MATERIALS



Name: Classical Mechanics
Author: P.S. Joag, N.C. Rana
Edition:
Publisher: McGraw Hall
ISBN: 978-0074603154



Name: Mechanics: Course of Theoretical Physics - Vol. 1
Author: L.D. Landau and E.M. Lifshitz:
Edition: 3rd Ed.
Publisher: CBSPD
ISBN: 978-8181477866



Name: Classical Mechanics
Author: John R. Taylor
Edition: 2004
Publisher: University Science Books
ISBN: John R. Taylor

6.0 MAPPING OF CLO TO PO AND PSO

The course outcomes and their mapping with program outcomes are specified in the table below

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CO3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

9.0 ASSESSMENT SCHEME

The evaluation system for this course consists of an 80% weightage on a comprehensive theory examination, which assesses students' understanding of various course topics, and a 20% weightage allocated to internal assessments, including internal examinations, assignments, class participation, and overall engagement in the course throughout the semester.

THEORY:

(A) Internal assessment: (20 marks): Continuous evaluation and internal assessment are implemented to foster and maintain a thorough understanding throughout the learning process. By regularly assessing comprehension through assignments, quizzes, and class participation, educators can address learning gaps promptly and support students in achieving deeper knowledge and proficiency in the subject matter.

(B) End-term examination (80 marks): The end-term examination serves as a culmination of students' learning in the course, assessing their comprehensive understanding and proficiency in various topics in the course. It provides a structured platform for students to demonstrate their knowledge, problem-solving abilities, and application of theoretical concepts, ultimately gauging their readiness to progress. Pattern of End term question paper

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B	5	10	3	30
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PRACTICUM:

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(B) End-term examination (80 marks): The ability to apply theoretical knowledge to real-world situations is the fundamental criterion used in the End Term examination. It typically involves students' activity on randomly assigned laboratory works and the Laboratory Report (Notebook) on the performed work in the entire semester. In the End examination, the student must complete randomly assigned tasks and prepare a report on their work, including appropriate conclusions. The mark distribution for the End term examination as follows.

Activity	Marks
Laboratory work in the Examination	40
Laboratory Notebook	20
Presentation/Viva-voce	20

PHY-001-CC-3130: QUANTUM MECHANICS

NCrF Level:	5.5	
Programme:	Four Year Undergraduate Programme	**Semester:** Fifth
Course Category:	Major Course (Core Course)	
Credit (L: T: P)	3: 0: 2	
Credit Hours	Theory: 45 Hours, Practicum: 60 Hours	

1.0 COURSE LEARNING OBJECTIVES

The aim of this course is to provide the foundational principles, mathematical formalism, and applications of quantum mechanics. The Learning outcomes of the course are:

- To be aware about the basic formulations in quantum mechanics. There are many different types of representations of state and operators that are very useful in studying the subject deeply
- To provide the skill to insight to solve Schrodinger wave equation under different circumstances
- to give information about Hermitian operators, their eigenvalues and eigenvectors. It teaches about various commutation and uncertainty relations.
- To provide the knowledge about unitary transformations, Dirac delta function, matrix representation of operators and their applications.

2.0 COURSE LEARNING OUTCOME

After completing this course, students will be able to,

CO	Outcomes
CO1:	Understand the chronological progression and key milestones in the development of quantum mechanics and learn about contributions of prominent physicists .
CO2:	Able to analyze the experimental evidence that led to the formulation of quantum mechanics with mathematical and theoretical frameworks
CO3:	Learn the principles and experimental evidence of wave-particle duality and to apply this knowledge to understand diffraction, interference, and the photoelectric effect.
CO4:	Grasp the concepts of the Heisenberg uncertainty principle and apply it to understand the limitations in simultaneously measuring pairs of complementary variables in quantum systems.
CO5:	Understand the concept of wave functions and their significance in describing the quantum state of a system using Schrodinger equation.
CO6:	Learn to apply the Schrödinger equation to solve for wave functions and energy levels in various potential scenarios, such as free particles, potential wells, and harmonic oscillators.
CO7:	understand the role of operators, their physical significance and to apply them in solving problems involving observables, eigenvalues, and eigenstates.
CO8:	Understand the solution of hydrogen atom and harmonic oscillator problem to determine eigenfunctions, energy spectra, and physical implications.
CO9:	Learn to apply Python libraries such as NumPy, SciPy, and QuTiP to simulate Schrödinger equation through numerical techniques.
CO10:	Able to prepare clear, structured, and concise scientific reports, effectively presenting about the performed exercise in the laboratory.

3.0 SKILLS TO BE LEARNED

- Develop proficiency in describing quantum systems using wavefunctions and operators
- To solve Schrödinger equation for various dynamical systems.
- To explore quantum mechanics from atomic physics to condensed matter physics,

4.0 DETAILED CONTENTS OF THE COURSE: THEORY

Credit: 3 **Classroom Teaching: 45 Horus**

MODULE 1

Quantum Theory: Failure to explain spectra of heated body using Newtonian mechanics and electromagnetism - Balmer series, Kirchhoff Theorem - Kirchhoff Experiment (derivation of Kirchhoff law). Physical model of a Black body, Stefan's Law, Black body radiation curve, Wien's displacement Law, Wien's exponential Law, Rayleigh-Jeans Law – ultraviolet catastrophe, Planck's Hypothesis – quanta, Planck's Law (derivation not necessary), Photoelectric effect – Hertz and Hallwachs experiment, Lenard's observations and failure of wave theory, Einstein expiation, Millikan's experiment. Compton effect – failure of classical theory, explanation through quantum theory of light, Compton Shift (Derivation). Bohr Theory – quantization of momentum and stable orbit, Specific Heat of Gases – quantization of energy and momentum, **[8 hours]**

Wave-particle duality: De Broglie hypothesis - justification of Bohr Theory, de Broglie quantization rule, concept of matter waves. Electron diffraction experiment - Davisson-Germer experiment, Thomson's experiment, Two-Slit experiment with electrons. Probability. Wave amplitude and wave functions. Two slit interference experiments with photons, atoms and particles; linear superposition principle as a consequence, Wave description of particles by wave packets. Group and Phase velocities and the relation between them, Bohr Complementarity principle, Correspondence principle **[5 hours]**

Uncertainty Principle: uncertainty in position and momentum, gamma ray microscope - thought experiment; consequences of uncertainty principle, energy time uncertainty – spectral broadening **[2 hours]**

MODULE 2

Wave functions and Schrodinger equation: Localized matter waves – wave packet, wave function, physical interpretation of a wave function, well-behaved wave functions, Probability and probability current densities, normalized wave functions, orthogonality of wave functions, Schrodinger equation – time dependent and time independent. Schrodinger equation from classical wave equation general solution of Schrodinger equation. Eigenvalue and eigenfunctions. Application to spread of Gaussian wave-packet for a free particle in one dimension; Fourier transforms and momentum space wavefunction, Superposition Principles, **[8 hours]**

Operators: Linear Operator, Momentum and energy operator in Schrodinger equation, Eigenfunctions and eigenvalues, simultaneous eigenfunction, commutation of operator, observables and expectation values, Expectation values of position and momentum. Wave Function of a Free Particle, Probability current density, Ehrenfest Theorem (equation of motion), Hermitian operators, completeness of eigenfunction Sets. Schmidt orthogonalization Procedure, compatibility, the commutation rule and Poisson brackets, commutator algebra, Operators for conserved quantifiers, Propagator, The viral theorem, Unitary operator. postulates of quantum mechanics [**7 hours]**

MODULE 3

General discussion of bound states in an arbitrary potential- continuity of wavefunction, boundary condition and emergence of discrete energy levels in One dimensional infinitely rigid box and one-dimensional problem-square well potential; Quantum mechanical scattering and tunneling in across a step potential & rectangular potential barrier. **[9 hours]**

Quantum mechanics of simple harmonic oscillator-energy levels and energy eigenfunctions using Frobenius method; Hermite polynomials; ground state, zero-point energy & uncertainty principle. **[3 hours]**

Quantum theory of hydrogen-like atoms: Radial wavefunctions from Frobenius method; shapes of the probability densities for ground & first excited states; quantum numbers [**3 hours]**

5.0 DETAILED CONTENTS OF THE COURSE: PRACTICUM

Credit: 2 | **Laboratory Work: 60 Hours**

In the practicum component of the course, students will undergo exercise related visualization of quantum mechanical phenomena as well as to solve problems using Python.

a) Visualizing wave functions and probability densities
b) Representing quantum states and operators using NumPy
c) Solving the Schrödinger equation using finite difference methods
d) Implementing time evolution using Crank-Nicolson method
e) Simulating quantum tunneling
f) Calculating expectation values and uncertainties
g) Visualizing uncertainty relations
h) Visualizing uncertainty relations

Using computational techniques solve the following problems based on quantum mechanics

1. Solve the s-wave Schrodinger equation for the ground state and the first excited state of the hydrogen atom
    a. $\frac{d^2y}{dt^2} = A(r), u(r)$, $A(r) = \frac{2m}{\hbar^2}[V(r) - E]$ where $V(r) = -\frac{e^2}{r}$Where $m \rightarrow$ is the reduced mass of the electron
    b. Obtain the energy eigenvalues and plot the corresponding wavefunctions. Remember that the ground state energy of the hydrogen atom is ≈ 13.6 eV. Take $e = 3.795\ (eV\text{Å})^{1/2}$, $\hbar c = 1973\ (eV\text{Å})$ and $m = 0.511 \times 10^6\ eV/c^2$
2. Solve the s-wave radial Schrodinger equation for an atom:
    a. $\frac{d^2y}{dt^2} = A(r), u(r)$, $A(r) = \frac{2m}{\hbar^2}[V(r) - E]$
    b. Where, m is the reduced mass of the system (which can be chosen to be the mass of an electron), for the screened coulomb potential
    c. $V(r) = -\frac{e^2}{r}e^{-\frac{r}{a}}$
    d. Find the energy (ineV)of the ground state of the atom to an accuracy of three significant digits. Also, plot the corresponding wavefunction. Take $m = 0.511 \times 10^6\ eV/c^2$, $e = 3.795\ (eV\text{Å})$ and $a = 3\text{Å}$, 5Å, 7Å . In these units $\hbar c = 1973\ (eV\text{Å})$. The ground state energy is expected to be above -12 eV in all three cases.
3. Solve the $s-$ wave radial Schrodinger equation for a particle of mass m

a. $\frac{d^2y}{dt^2} = \boldsymbol{A(r), u(r)}, \quad \boldsymbol{A(r)} = \frac{2m}{\hbar^2}[\boldsymbol{V(r) - E}]$

i. For a harmonic oscillator potential

b. $V(r) = \frac{1}{2}kr^2 + \frac{1}{3}br^3$

c. For the ground state energy $(inMeV)$ of particle to an accuracy of three significant digits. Also, plot the corresponding wave function. Choose $m = 940\ MeV/c^2$, $k = 100\ MeVfm^{-2}, b = 0,\ 10,\ 30\ MeVfm^{-3}$. In these units $c\hbar = 197.3\ MeVfm$. The ground state energy is accepted to lie between 90 and 110 MeV for all three cases.

4. Solve the s − wave radial Schrodinger equation for the vibrations of hydrogen molecule

a. $\frac{d^2y}{dt^2} = \boldsymbol{A(r), u(r)}, \quad \boldsymbol{A(r)} = \frac{2\mu}{\hbar^2}[\boldsymbol{V(r) - E}]$

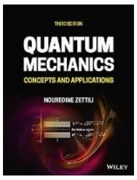
i. Where, $\mu \rightarrow$ reduced mass of the two atom system for Morse potential

b. $V(r) = D\left(e^{-2ar'} - e^{-ar'}\right),\ r' = \frac{r - r_0}{r}$

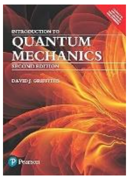
c. Find the lowest vibrational energy $(inMeV)$ of the molecule to an accuracy of three significant digits. Also plot the correspond wave function.

d. Take: $\mathrm{m = 940\ MeV/c^2}$, $\mathrm{D = 0.755501\ eV}$, $\alpha = 1.44.\ \mathrm{r_0 = 0.13349}$

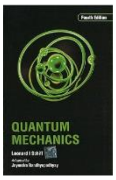
6.0 TEXT BOOKS



Name: Quantum Mechanics Concepts and Applications
Author: Nouredine Zettili
Edition: 3rd Ed.
Publisher: Wiley
ISBN: 978-1118307892

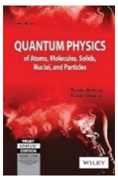


Name: Introduction to Quantum Mechanics
Author: D.J. Griffith
Edition: 2nd Ed.
Publisher: Pearson Education
ISBN: 978-9332542891

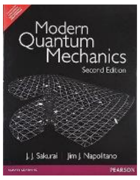


Name: Quantum Mechanics
Author: Leonard I. Schiff and Jayendra Bandyopadhyay
Edition: 3rd Ed.. 2010
Publisher: Tata McGraw Hill
ISBN: 978-1259062865

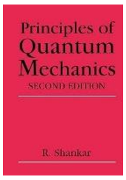
7.0 REFERENCE BOOKS AND MATERIALS



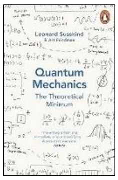
Name: Quantum Physics of Atoms, Molecules, Solids, Nuclei and Particles
Author: Robert Eisberg and Robert Resnick
Edition: 2nd Edn., 2002
Publisher: Wiley
ISBN: 978-8126508181



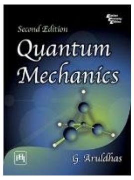
Name: Modern Quantum Mechanics
Author: J. J. Sakurai and Jim Napolitano
Edition: 2nd Ed.
Publisher: Pearson Education India
ISBN: 978-9332519008



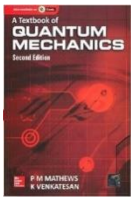
Name: Principles of Quantum Mechanics
Author: R. Shankar
Edition: 2nd Ed. (2014)
Publisher: Springer
ISBN: 978-0306447907



Name: Quantum Mechanics: The Theoretical Minimum
Author: Leonard Susskind and Art Friedman
Edition: 2015
Publisher: Penguin Books Ltd
ISBN: 978-0141977812



Name: Quantum Mechanics
Author: G. Aruldhas
Edition: 2nd Edn. 2002
Publisher: PHI Learning of India
ISBN: 978-8120336353



Name: A Text book of Quantum Mechanics
Author: P.M.Mathews and K.Venkatesan
Edition: 2nd Ed., 2010
Publisher: McGraw Hill Education
ISBN: 978-0070146174

6. 0 MAPPING OF CLO TO PO AND PSO

The course outcomes and their mapping with program outcomes are specified in the table below

Course Learning Outcomes	Programme Outcomes (POs)												Programme Specific Outcome (PSOs)					
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6
CO1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

9.0 ASSESSMENT SCHEME

The evaluation system for this course consists of an 80% weightage on a comprehensive theory examination, which assesses students' understanding of various course topics, and a 20% weightage allocated to internal assessments, including internal examinations, assignments, class participation, and overall engagement in the course throughout the semester.

THEORY:

(A) Internal assessment: (20 marks): Continuous evaluation and internal assessment are implemented to foster and maintain a thorough understanding throughout the learning process. By regularly assessing comprehension through assignments, quizzes, and class participation, educators can address learning gaps promptly and support students in achieving deeper knowledge and proficiency in the subject matter.

(B) End-term examination (80 marks): The end-term examination serves as a culmination of students' learning in the course, assessing their comprehensive understanding and proficiency in various topics in the course. It provides a structured platform for students to demonstrate their knowledge, problem-solving abilities, and application of theoretical concepts, ultimately gauging their readiness to progress. Pattern of End term question paper

Section	Total Questions	Marks for each question	have to attempt	Total Marks
A	5	4	4	20
B	5	10	3	30
C	4	15	2	30

PRACTICUM:

(A) Internal assessment: (20 marks): In the internal assessment of the practicum components, the student's performance, understanding, skills, sincerity, and involvement in laboratory work during the entire semester are evaluated.

(B) End-term examination (80 marks): The ability to apply theoretical knowledge to real-world situations is the fundamental criterion used in the End Term examination. It typically involves students' activity on randomly assigned laboratory works and the Laboratory Report (Notebook) on the performed work in the entire semester. In the End examination, the student must complete randomly assigned tasks and prepare a report on their work, including appropriate conclusions. The mark distribution for the End term examination as follows.

Activity	Marks
Laboratory work in the Examination	40
Laboratory Notebook	20
Presentation/Viva-voce	20

PHY-001-CC-3140: ELECTRONICS II

NCrF Level:	4.5	
Programme:	Four Year Undergraduate Programme	**Semester:** Fifth
Course Category:	Major Course (Core Course)	
Credit (L: T: P)	3: 0: 2	
Credit Hours	Theory: 45 Hours, Practicum: 60 Hours	

1.0 COURSE OBJECTIVES

This course aims to deliver students with a comprehensive understanding of the principles and applications of operational amplifiers (op-amps) and digital electronics. The Learning Objectives of the course are:

- To provide the construction characteristics, configurations, and applications in analog electronics, including circuit analysis, design, and troubleshooting.
- To enrich the knowledge on the principles of digital logic including Boolean algebra, logic gates, combinational and sequential circuits.
- To provide proficiency in designing and implementing digital circuits using tools like logic gates, flip-flops, registers, and analyze their behavior using simulation and testing.
- Furnish basic principles and components of digital communication systems, including modulation techniques, coding schemes, and signal processing.

2.0 COURSE LEARNING OUTCOME

After completing this course, students will be able to,

CO	Outcomes
CO1:	understand the principle of differential amplifier and operational amplifier along with the advantages and disinvites of different circuit configurations used in electronics
CO2:	Learn to design, analyze, and implement various analog circuits using operational amplifiers, including amplifiers, filters, and oscillators.
CO3:	Learn the about different types of number systems, their conversion techniques and the use of Boolean Algebra in designing digital circuit
CO4:	Learn to design, analyze, and implement combinational logic circuits using gates, multiplexers, demultiplexers, encoders, decoders, and arithmetic circuits such as adders and subtractors.
CO5:	Learn to design and analyze sequential logic circuits including various types of flip-flops, counters, and shift registers, and understand their applications in digital systems
CO6:	Learn the principle behind the Digital to Analog and Analog to Digital conversion circuit as well as to design and create such circuits for different applications.
CO7:	Learn the fundamental principles of digital communication systems, including signal processing, modulation, and demodulation techniques.
CO8:	Gain hands-on experience in designing, building, testing, and analyzing various op-amp circuits, including amplifiers, filters, and signal conditioning circuits.
CO9:	Enrichen hands-on experience in designing, building, testing of logic gates, multiplexers, flip-flop, register, counter as well as digital to analog converter and analog to digital converters.
CO10:	Able to document clear structured scientific reports of experimental works in the laboratory effectively and to troubleshoot circuits.

3.0 SKILLS TO BE LEARNED

- Circuit design and development of OP-AMP based circuits
- Design of digital circuits for a specific application

4.0 DETAILED CONTENTS OF THE COURSE: THEORY

Credit: 3 **Classroom Teaching: 45 Horus**

MODULE 1

Operational Amplifier: Differential amplifier (transistor based), Block diagram of op-amp, equivalent circuit, Characteristic of parameters of op-amp (input-offset Voltage, input bias current, input offset current, total output offset voltage, CMRR, slew rate etc.) frequency response of an Op-amp, open loop configurations and closed loop configuration, Op-amp with negative feedback: Voltage series feedback – effect of feedback, bandwidth and output offset voltage, voltage follower, Mathematical operations - summing, scaling and averaging amplifiers, integrator and differentiator, Op-amp as Oscillator: types, frequency stability, response. The phase shift oscillator and LC tunable oscillator. Op-amp in nonlinear applications - comparators, function generators, Multivibrators, Op-amp as instrumentation amplifier **[15 hours]**

MODULE 2

Number systems decimal, binary, octal and hexadecimal number system, conversion from one number system to another, BCD code, XS-3 code, Gray code, Error detecting code, Hamming code, Alphanumeric code. **[3 hours]**

Logic gates: Logic gates - AND, OR and NOT Gates (realization using Diodes and Transistor),. NAND and NOR Gates as Universal Gates. XOR and XNOR Gates and application as Parity Checkers. TTL and CMOS, logic – characteristics. **[3 hours]**

Boolean algebra: Laws of Boolean algebra, De Morgan's Theorems. Simplification of Logic Circuit using Boolean Algebra. Min-terms and Max-terms. Sum of Product and Product of Sum, Conversion of a Truth table into Equivalent Logic Circuit by (1) Sum of Products Method and (2) Karnaugh Map. **[5 hours]**

Combinational Circuits: Data processing circuits- Multiplexers, De-multiplexers, Decoders, Encoders. Arithmetic Circuits- Binary Addition. Binary Subtraction using 2's Complement. Half and Full Adders. Half & Full Subtractors, 4-bit binary Adder/Subtractor **[4 hours]**

MODULE 3

Sequential Circuits: SR, D, and JK Flip-Flops. Clocked (Level and Edge Triggered) Flip-Flops. Preset and Clear operations. Race-around conditions in JK Flip-Flop. M/S JK Flip-Flop. <u>multivibrators using IC 555</u>**.** Shift registers (4 bits) - Serial-in-Serial-out, Serial-in-Parallel-out, Parallel-in-Serial-out and Parallel-in-Parallel-out. Counters - Ring Counter Asynchronous counters, Synchronous Counter. Design of Counter **[10 hours]**

A/D and D/A conversion: Resistive network (Weighted and R-2R Ladder). Accuracy and Resolution. A/D Conversion (successive approximation), resolution and speed; **[2 hours]**

Digital Electronic communications: Modulation and its importance - transmitter and receiver (AM and FM), Digital communication - Continuous wave modulation and Pulse modulation, ASK, BPSK, M-PSK, QAM, FSK, MSK, Structure of Digital transmitter and receiver. **[3 hours]**

5.0 DETAILED CONTENTS OF THE COURSE: PRACTICUM

Credit: 2 **Laboratory Work: 60 Hours**

In the practicum component of the course, students will undergo a number of experiments with operational amplifier and digital electronics components.

Students are required to conduct experiments from the provided list, meticulously following the suggested procedures and protocols outlined for each. Subsequently, they must compile comprehensive reports for every experiment, adhering to scientific standards and conventions. These reports should encompass a detailed description of the experimental setup and methodology employed, including any modifications made during the course of the experiment. Furthermore, students are expected to record and analyze their experimental data systematically, drawing upon relevant theoretical concepts and principles to interpret their findings accurately. Additionally, the reports should include a thorough discussion of the results obtained, highlighting any observed trends, anomalies, or correlations, and offering insightful explanations or hypotheses where applicable. Moreover, students must demonstrate proficiency in presenting their results graphically, utilizing tables, figures, and diagrams to enhance clarity and facilitate comprehension. Finally, each report should conclude with a succinct summary of the key findings and conclusions drawn from the experiment, along with any recommendations for further investigation or improvement.

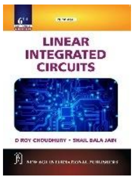
The teacher has the flexibility to introduce a wide range of laboratory experiments that directly correlate with and reinforce the theoretical concepts covered in the course curriculum. These experiments serve as practical applications of the theoretical principles discussed in lectures.

(A) Suggested List of Experiments:

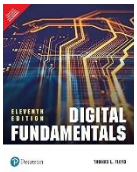
1. For a given OP-AMP the Transfer curve of OP-Amp and measure (i) input offset voltage (ii) offset current (iii) input bias current (iv)CMRR (v) Slew rate
2. To study the OP-AMP as an (a) Inverting amplifier (b) Non-inverting amplifier (c)A unity gain buffer (d) differential amplifier
3. Study of Operational Amplifier as an Adding Amplifier, average amplifier and Scaling Amplifier
4. To study the performance of an OP-AMP as a Differentiator and Integrator.
5. To construct a logarithmic amplifier and antilog(exponential) amplifier using an OP AMP and to study its performance
6. Study of an OP-AMP as voltage to current and current to voltage Converter
7. To study the performance of a simple voltage comparator using OP-AMP
8. To study the performance of the weighted-resistor digital-to-analog (D/A) converter using OP-AMP
9. To study the performance of R-2R ladder digital-to-analog (D/A) converter using OP-AMP
10. Study of Operational amplifier as a comparator and zero crossing detector and to study Operational amplifier as a schmitt trigger.
11. Construction of AND,OR,NOT,XOR,XNOR using resistor, diode and transistor.
12. Design and construction of half adder, half subtractor, full adder and full subtractor using Universal gates.
13. Design and construction of half subtractor and full subtractor using Universal gates.
14. Design and construction of binary to gray code conversion circuit & Vice-Versa.
15. Design and construction of binary to XS-3 code conversion circuit & Vice-Versa.
16. To design and implement encoder and decoder
17. To design and implement multiplexer and demultiplexer
18. Four-bit parity generator and comparator circuits
19. Design of combinational circuit for BCD to decimal conversion to drive 7-segment display using multiplexer.
20. To design and construct basic flip-flops (RS, JK and D Type)using Universal logic gates
21. Realization of Universal Register using JK flip-flops and logic gates.
22. Realization of Universal Register using multiplexer and flip-flops.

23. To design and construct a Synchronous Up/Down counter.
24. To design and construct Asynchronous Up/Down counters.
25. Realization of Ring counter and Johnson's counter.
26. Design of Sequential Counter with irregular sequences. 20 Programming on microprocessor

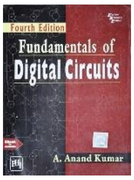
TEXT BOOKS



Name: Linear Integrated Circuits
Author: D. Roy Choudhury and Shail B. Jain
Edition: 6th Ed.
Publisher: New Age International Private Limited
ISBN: 978-8122472127

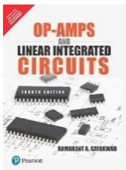


Name: Digital Fundamentals
Author: Thomas L. Floyd
Edition: 11th Ed (2017)
Publisher: Pearson Education
ISBN: 978-9332584600

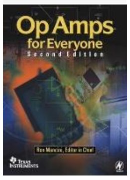


Name: Fundamentals of Digital Circuits
Author: A. Anand Kumar
Edition: 4th Ed.
Publisher: PHI Learning Pvt. Ltd.
ISBN: 978-8120352681

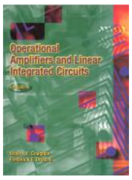
REFERENCE BOOKS AND MATERIALS



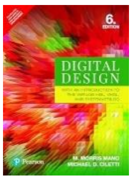
Name: Op-Amps and Linear Integrated Circuits
Author: Ramakant A. Gayakwad
Edition: 4th Ed.
Publisher: Pearson
ISBN: 978-9332549913



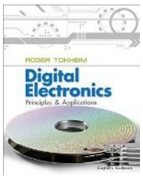
Name: Op Amps for Everyone: Design Reference
Author: Ron Mancini
Edition: 2nd Ed.
Publisher: Newnes
ISBN: 978-0750677011



Name: Operational Amplifiers and Linear Integrated Circuits
Author: Robert F. Coughlin and Frederick F. Driscoll
Edition: 6th Ed.
Publisher: Pearson
ISBN: 978-0130149916



Name: Digital Design
Author: M. Morris Mano and Michael D. Ciletti
Edition: 6th Ed.
Publisher: Pearson Education
ISBN: 978-9353062019



Name: Digital Electronics: Principles and Applications
Author: Roger L. Tokheim
Edition: 8th Ed.
Publisher: McGraw-Hill Education
ISBN: 978-0073373775

Name: Digital Communication Systems
Author: Simon Haykin
Edition: 2013
Publisher: Wiley India
ISBN: 978-9354242465

0 MAPPING OF CLO TO PO AND PSO

The course outcomes and their mapping with program outcomes are specified in the table below

Course Learning Outcomes	Programme Outcomes (POs)												Programme Specific Outcome (PSOs)					
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CO3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

9.0 ASSESSMENT SCHEME

The evaluation system for this course consists of an 80% weightage on a comprehensive theory examination, which assesses students' understanding of various course topics, and a 20% weightage allocated to internal assessments, including internal examinations, assignments, class participation, and overall engagement in the course throughout the semester.

THEORY:

(A) Internal assessment: (20 marks): Continuous evaluation and internal assessment are implemented to foster and maintain a thorough understanding throughout the learning process. By regularly assessing comprehension through assignments, quizzes, and class participation, educators can address learning gaps promptly and support students in achieving deeper knowledge and proficiency in the subject matter.

(B) End-term examination (80 marks): The end-term examination serves as a culmination of students' learning in the course, assessing their comprehensive understanding and proficiency in various topics in the course. It provides a structured platform for students to demonstrate their knowledge, problem-solving abilities, and application of theoretical concepts, ultimately gauging their readiness to progress. Pattern of End term question paper

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(A) Internal assessment: (20 marks): In the internal assessment of the practicum components, the student's performance, understanding, skills, sincerity, and involvement in laboratory work during the entire semester are evaluated.

(B) End-term examination (80 marks): The ability to apply theoretical knowledge to real-world situations is the fundamental criterion used in the End Term examination. It typically involves students' activity on randomly assigned laboratory works and the Laboratory Report (Notebook) on the performed work in the entire semester. In the End examination, the student must complete randomly assigned tasks and prepare a report on their work, including appropriate conclusions. The mark distribution for the End term examination as follows.

Activity	**Marks**
Laboratory work in the Examination	40
Laboratory Notebook	20
Presentation/Viva-voce	20

PHY-001-CC-3210: STATISTICAL MECHANICS

NCrF Level: 5.5

Programme: Four Year Undergraduate Programme **Semester:** Sixth

Course Category: Major Course (Core Course)

Credit (L: T: P) 3: 0: 1

Credit Hours Theory: 45 Hours, Practical: 30 Hours

1.0 COURSE LEARNING OBJECTIVES

This course provides the knowledge to evaluate macroscopic parameters of a physical system from the underlying microscopic behavior of atoms and molecules that comprises it. The Learning objectives of the Course are:

- To provide probability and its importance in the study of a thermodynamic system.
- to apply the principles of probability in distribution of particles in various systems and to calculate thermodynamic probability.
- To enlighten about different types of statistics distribution and their applications.

2.0 COURSE LEARNING OUTCOME

After completing this course, students will be able to,

CO	Outcomes
CO1:	Gain a comprehensive understanding of different statistical ensembles such as microcanonical, canonical, and grand canonical ensembles, and their relevance in describing physical systems.
CO2:	Learn to calculate and interpret partition functions for various systems, including classical and quantum mechanical systems, and apply them to derive thermodynamic properties..
CO3:	Develop skills to derive thermodynamic quantities such as entropy, temperature, pressure, and free energy from partition functions and ensemble averages.
CO4:	Learn to apply principles to statistical mechanics to analyze and predict the behavior of physical systems including gasses, liquids, solids, and phase transitions .
CO5:	Get the knowledge on application, and physical interpretation of Maxwell's thermodynamic relations to analyze and predict the behavior of complex systems in equilibrium.
CO6:	Achieve a comprehensive understanding of the behavior of bosons and fermions in quantum systems under different circumstances.
CO7:	Get a comprehensive understanding of Fermi-Dirac statistics and their applications in describing the behavior of fermionic systems
CO8:	To implement, visualize and analyze fundamental concepts of statistical mechanics through computer programming.

3.0 SKILLS TO BE LEARNED

- To apply classical statistics to the theory of radiation.
- To use quantum statistics to understand the behaviour of bosons and fermions
- To visualize various physical phenomena though computer programming

4.0 DETAILED CONTENTS OF THE COURSE: THEORY

Credit: 3 **Classroom Teaching: 45 Horus**

MODULE 1

Review of thermodynamics and probability theory: Quasistatic and non quasi static processes, laws of thermodynamics, entropy of a probability distribution, random walks - Langevin' Theory of Brownian Motion. **[2 hours]**

Classical Statistics: Macrostate & Microstate, Elementary Concept of Ensemble, Phase Space, Entropy and Thermodynamic Probability, Maxwell-Boltzmann Distribution Law, Partition Function, Thermodynamic Functions of an Ideal Gas, Classical Entropy Expression, Gibbs Paradox, Sackur Tetrode equation, Law of Equipartition of Energy (with proof) – Applications to specific heat, ideal diatomic gas, Classical harmonic oscillator, magnetic dipoles in a magnetic field. Inadequacy of classical theory, Thermodynamic Functions of a Two-Energy Levels System, Negative Temperature. **[13 Lectures]**

MODULE 2

Theory of Radiation: Properties of Thermal Radiation. Blackbody Radiation. Pure temperature dependence. Kirchhoff's law. Stefan-Boltzmann law: Thermodynamic proof. Radiation Pressure. Wien's Displacement law. Wien's Distribution Law. Saha's Ionization Formula. Rayleigh-Jeans Law. Ultraviolet Catastrophe. Planck's Quantum Theory of Black body radiation, Experimental verification and deduction of PLanck's law of Radiation, **[6 Lectures]**

Bose-Einstein Statistics: B-E distribution law, Thermodynamic functions of a strongly Degenerate Bose Gas, Bose Einstein condensation, properties of liquid He (qualitative description), Radiation as a photon gas and Thermodynamic functions of photon gas. Bose derivation of Planck's law. **[9 hours]**

MODULE 3

Fermi-Dirac Statistics: Fermi-Dirac Distribution Law, Thermodynamic functions of a Completely and strongly Degenerate Fermi Gas, Fermi Energy, Electron gas in a Metal, Specific Heat of Metals, Relativistic Fermi gas, White Dwarf Stars, Chandrasekhar Mass Limit. **[6 Hours]**

Interacting systems and phase transitions: Interacting spin systems. The Ising model. Exact solution of Ising model in 1-dimension, mean-field solution in higher dimensions. Paramagnetic and ferromagnetic phases. Critical exponents. Order parameter, Landau theory, Universality. **[9 Hours]**

5.0 DETAILED CONTENTS OF THE COURSE: PRACTICUM

Credit: 1 **Laboratory Work: 30 Hours**

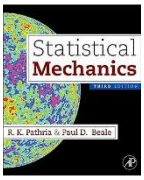
In the practicum component of the course, students will undergo exercise related to visualization and problem solving through computational techniques.

1. Computational analysis of the behavior of a collection of particles in a box that satisfy Newtonian mechanics and interact via the Lennard-Jones potential, varying the total number of particles N and the initial conditions:
    a) Study of local number density in the equilibrium state (i) average; (ii) fluctuations
    b) Study of transient behavior of the system (approach to equilibrium)
    c) Relationship of large N and the arrow of time
    d) Computation of the velocity distribution of particles for the system and comparison with the Maxwell velocity distribution
    e) Computation and study of mean molecular speed and its dependence on particle mass

f) Computation of fraction of molecules in an ideal gas having speed near the most probable speed

2. Computation of the partition function Z(β) for examples of systems with a finite number of single particle levels (e.g., 2 level, 3 level, etc.) and a finite number of non-interacting particles N under Maxwell-Boltzmann, Fermi-Dirac and Bose-Einstein statistics:
   a) Study of how Z(β), average energy <E>, energy fluctuation ΔE, specific heat at constant volume Cv, depend upon the temperature, total number of particles N and the spectrum of single particle states.
   b) Ratios of occupation numbers of various states for the systems considered above
   c) Computation of physical quantities at large and small temperature T and comparison of various statistics at large and small temperature T.
3. Plot Planck's law for Black Body radiation and compare it with Rayleigh-JeansRaleigh-Jeans Law at high temperature and low temperature
4. Plot Specific Heat of Solids (a) Dulong-Petit law, (b) Einstein distribution function, (c) Debye distribution function for high temperature and low temperature and compare them for these two cases.
5. Plot the following functions with energy at different temperatures
   a) Maxwell-Boltzmann distribution
   b) Fermi-Dirac distribution
   c) Bose-Einstein distribution.

6.0 TEXT BOOKS



Name: Statistical Mechanics
Author: R.K. Pathria and Paul D. Beale
Edition: 3rd Ed.
Publisher: Academic Press
ISBN: 978-0123821881

Name: Statistical Mechanics
Author: Kerson Huang
Edition: 2nd Ed.
Publisher: Wiely
ISBN: 978-9354247736

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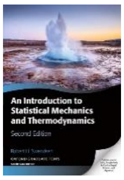
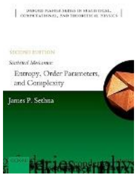
7.0 REFERENCE BOOKS AND MATERIALS



Name: An Introduction to Statistical Mechanics and Thermodynamics
Author: Robert H. Swendsen
Edition: 2nd Ed.
Publisher: Oxford University Press
ISBN: 978-0198863922



Name: Statistical Mechanics: Entropy, Order Parameters, and Complexity
Author: James P. Sethna
Edition: 2nd Ed.
Publisher: Oxford University Press
ISBN: 978-0198865247

6.0 MAPPING OF CLO TO PO AND PSO

The course outcomes and their mapping with program outcomes are specified in the table below

Course Learning Outcomes	Programme Outcomes (POs)												Programme Specific Outcome (PSOs)					
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6
CO1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

9.0 ASSESSMENT SCHEME

The evaluation system for this course consists of an 80% weightage on a comprehensive theory examination, which assesses students' understanding of various course topics, and a 20% weightage allocated to internal assessments, including internal examinations, assignments, class participation, and overall engagement in the course throughout the semester.

THEORY:

(A) Internal assessment: (20 marks): Continuous evaluation and internal assessment are implemented to foster and maintain a thorough understanding throughout the learning process. By regularly assessing comprehension through assignments, quizzes, and class participation, educators can address learning gaps promptly and support students in achieving deeper knowledge and proficiency in the subject matter.

(B) End-term examination (80 marks): The end-term examination serves as a culmination of students' learning in the course, assessing their comprehensive understanding and proficiency in various topics in the course. It provides a structured platform for students to demonstrate their knowledge, problem-solving abilities, and application of theoretical concepts, ultimately gauging their readiness to progress. Pattern of End term question paper

Section	Total Questions	Marks for each question	have to attempt	Total Marks
A	5	4	4	20
B	5	10	3	30
C	4	15	2	30

PRACTICUM:

(A) Internal assessment: (20 marks): In the internal assessment of the practicum components, the student's performance, understanding, skills, sincerity, and involvement in laboratory work during the entire semester are evaluated.

(B) End-term examination (80 marks): The ability to apply theoretical knowledge to real-world situations is the fundamental criterion used in the End Term examination. It typically involves students' activity on randomly assigned laboratory works and the Laboratory Report (Notebook) on the performed work in the entire semester. In the End examination, the student must complete randomly assigned tasks and prepare a report on their work, including appropriate conclusions. The mark distribution for the End term examination as follows.

Activity	Marks
Laboratory work in the Examination	40
Laboratory Notebook	20
Presentation/Viva-voce	20

PHY-001-CC-3220: ATOMIC PHYSICS

NCrF Level:	5.5	
Programme:	Four Year Undergraduate Programme	**Semester:** Sixth
Course Category:	Major Course (Core Course)	
Credit (L: T: P)	3: 0: 2	
Credit Hours	Theory: 45 Hours, Practicum: 60 Hours	

1.0 COURSE LEARNING OBJECTIVES

The Aim of this course is to provide fundamental concepts and mathematical models of atomic structure, spectra, and interactions, and apply quantum mechanics to analyze and solve problems involving atoms and their behaviour in different physical contexts. The Learning objectives of the course are:

- To explain historical development of atomic theory from early models (Dalton, Thomson, Rutherford) to modern quantum mechanics (Bohr, Schrödinger).
- To analyze atomic spectra and electronic transitions using quantum mechanical principles, including selection rules and emission/absorption processes.
- To Explain the effects of external fields on atomic systems (Zeeman and Stark effects) and apply these concepts to practical applications.

2.0 COURSE LEARNING OUTCOME

After completing this course, students will be able to,

CO	Outcomes
CO1:	Gain insight into contributions of various cultures and scientists in the evaluation of atomic theory from ancient civilization to modern scientific advancements.
CO2:	Understand Bohr and Sommerfeld models to describe the quantization of electron orbits and energy levels in atoms, and analyze their limitations.
CO3:	Learn to apply vector atom models to understand and analyze atomic structure, electron behaviour and interactions with electromagnetic fields, using quantum mechanical principles.
CO4:	Understand how electric and magnetic fields influence atomic energy levels and explain the resulting Zeeman and Stark effects in atomic spectra.
CO5:	Understand electronic structure and electron-electron interactions to explain spectral lines and fine structure of Helium atoms using the vector atom model.
CO6:	Able to understand, analyze, and interpret the spectral lines of alkali and alkaline metals using both theoretical principles and experimental techniques.
CO7:	Able to understand and analyze the rotational, vibrational, and electronic spectra of molecules, applying both theoretical concepts and experimental techniques.
CO8:	Learn to Conduct and analyze experiments related to atomic physics, demonstrating proficiency in using experimental apparatus and interpreting data accurately.
CO9:	Learn to apply theoretical principles to explain experimental results, critically evaluate methodologies, and effectively communicate findings in both written and oral formats.
CO10:	Able to prepare clear, structured, and concise scientific reports, effectively presenting laboratory works and findings with enhanced clarity.

3.0 SKILLS TO BE LEARNED

- use of advanced laboratory equipment and techniques for conducting experiments in atomic physics, including spectroscopy and particle detectors.
- Analyze experimental data accurately, apply statistical methods, and interpret results within the framework of atomic theory.
- Apply quantum mechanical models and theoretical concepts to solve complex problems in atomic physics, enhancing critical thinking and problem-solving abilities.

4.0 DETAILED CONTENTS OF THE COURSE: THEORY

Credit: 3 **Classroom Teaching: 45 Hours**

MODULE 1

Historical Development of Atomic Theory: Democritus Theory versus Aristotle's four element theory, Epicurus and Lucretius contribution to atomic theory, Concept of atom among Indian philosophers -atomic theory of Nyaya and Vaisheshika , Acharya Kanad- Vaisheshik Darshan, Atomic Theory in Jain philosopher, Robert Boyle on constitute of matter, Corpuscular Theory, concept of charge by Benjamin Franklin, Dalton's atomic theory, Kinetic Theory of Gases (measurement of atomic size and mass), atomic spectra of Kirchhoff and Bunsen, Mendeleev Periodic table, Maxwell's concept of atom, radioactivity (Henri Becquerel, P. curie and M. Nurie), George Johnstone Stoney and electron (electrine), Joseph John Thomson – discovery of electron. Cathode Ray experiment, Millikan oil-drop experiment - determination of e/m , Positive Rays - Thomson's Parabola Method, Mass Spectrograph , Hydrogen spectra, Balmer's Law, Rydberg's Contribution, **(5 hours)**

Modern Atomic Theory: Thomson's Model, Rutherford's Model- alpha scattering experiment, Borh's Atomic theory – Hydrogen spectra, Bohr Model with finite nuclear mass consideration, variation of Rydberg constant with mass number, Bohr's Correspondence principle, Drawback of Bohr's Model, Resonance potential, Excitation potential, Ionization potential, Frank Hertz Experiment, Sommerfeld Model, Wilson-Sommerfeld come up with quantization rules, success and failure of Sommerfeld Model, **(10 hours)**

MODULE 2

Vector Atom Model: quantum numbers associated with vector atom model,Orbital angular momentum and spin angular momentum, Space quantization. Orbital Magnetic moment - Bohr Magneton. Larmor's Theorem – Larmor frequency, Spin Magnetic Moment. Stern- Gerlach Experiment, Gyromagnetic Ratio, spin orbit interaction- Landé g-factor, spectroscopic terms, relativistic correction, Fine structure of Hydrogen atom – relativistic correction, Dirac equation, Lamb shift, hyperfine structure of spectral lines, determination of nuclear spin. Breadth of spectral lines **[12 hours]**

Atoms in External Magnetic Fields: - Normal and Anomalous Zeeman Effect (quantum mechanical treatment). Paschen-Back and Stark Effect (Qualitative Discussion only). **[3 hours]**

MODULE 3

Helium atom: Identical particle**,** Pauli's Exclusion Principle. Symmetric & Antisymmetric Wave Functions, slater determinant, symmetric and antisymmetric wave function in Helium atom, spectra of Helium atom – ortho and para, splitting of spectra line, excited states, doubly excited states, Auger effect, **[4 hours]**

Alkali and Alkaline Spectra: Spectral series in alkali spectra, Ritz Combination principle, variation of alkali spectra of hydrogen and other hydrogen like atoms, Fine structure of alkali atoms (L, Na, K etc.), intensity of fine structure lines (doublets), Alkaline Spectra **-** Hund's rule, L-S and j-j coupling schemes, Interaction energy in L-S and j-j coupling – example. **[4 hours]**

Molecular Spectra: Physics behind the molecular spectra, Born-Oppenheimer approximation, rotational spectra, non-rigid rotator, vibrational-rotational spectra of diatomic molecule, effect of anharmonicity, electronic spectra of diatomic molecules. Frank-Condon principle. **[7 hours]**

5.0 DETAILED CONTENTS OF THE COURSE: PRACTICUM

Credit: 2 **Laboratory Work: 60 Hours**

In the practicum component of the course, students will undergo experiment related to atomic phenomena of material. Through a series of practical exercises, students will enrich their theocratical concept about the atom. to draw various curves, analyse their properties, and understand their applications.

Students are required to conduct experiments from the provided list, meticulously following the suggested procedures and protocols outlined for each. Subsequently, they must compile comprehensive reports for every experiment, adhering to scientific standards and conventions. These reports should encompass a detailed description of the experimental setup and methodology employed, including any modifications made during the course of the experiment. Furthermore, students are expected to record and analyze their experimental data systematically, drawing upon relevant theoretical concepts and principles to interpret their findings accurately. Additionally, the reports should include a thorough discussion of the results obtained, highlighting any observed trends, anomalies, or correlations, and offering insightful explanations or hypotheses where applicable. Moreover, students must demonstrate proficiency in presenting their results graphically, utilizing tables, figures, and diagrams to enhance clarity and facilitate comprehension. Finally, each report should conclude with a succinct summary of the key findings and conclusions drawn from the experiment, along with any recommendations for further investigation or improvement.

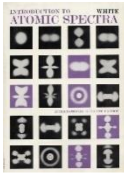
The teacher has the flexibility to introduce a wide range of laboratory experiments that directly correlate with and reinforce the theoretical concepts covered in the course curriculum. These experiments serve as practical applications of the theoretical principles discussed in lectures.

Suggestive list of experiment:

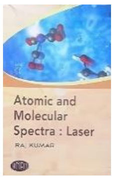
1. To study the quantized energy levels in atoms by measuring the energy exchange between electrons and mercury atoms using Franck-Hertz experiment.
2. To determine the elementary electric charge by observing the motion of charged oil droplets in an electric field through Millikan Oil Drop Experiment.
3. To study the emission of electrons from a metal surface when light of varying frequencies is incident upon it, confirming the quantized nature of light. (Photoelectric effect)
4. To study the splitting of spectral lines in the presence of a magnetic field, providing evidence for the quantization of angular momentum. (Zeeman Effect exit)
5. Measurement of Planck's constant using black body radiation and photo-detector.
6. To determine the work function of material of filament of directly heated vacuum diode.
7. To determine the wavelength of the H-alpha emission line of Hydrogen atoms.
8. To determine the absorption lines in the rotational spectrum of Iodine vapour.
9. To determine the value of e/m by (a) Magnetic focusing or (b) Bar magnet
10. To observe and analyze the electron spin resonance of a paramagnetic sample.
11. To study the nuclear magnetic resonance of a sample containing nuclei with spin quantum numbers.
12. To study the spectral lines emitted or absorbed by atoms and to determine the energy levels and transitions within the atomic structure.
13. Observing the characteristic yellow emission line of sodium atoms when heated in a flame, used for qualitative analysis of sodium compounds.

14. Using a flame to vaporize and atomize a sample, then measuring the intensity of light emitted by specific atomic transitions to quantify the concentration of certain elements.
15. Exciting atoms in a sample with high-voltage sparks and analyzing the resulting emission spectrum to identify elements and study their energy levels.
16. Using an electric arc to vaporize and excite atoms in a sample, then analyzing the emission spectrum to identify elements and study their properties.

6.0 TEXT BOOKS

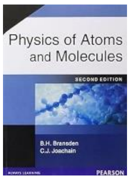


Name: Atomic Spectra
Author: Harvey Elliott White
Edition: 2019
Publisher: McGraw Hill Education
ISBN: 978-9352604777

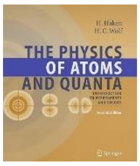


Name: Atomic and Molecular Physics
Author: Raj Kumar
Edition:
Publisher: Kedar Nath Ram Nath
ISBN: 978-8180300356

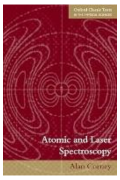
7.0 REFERENCE BOOKS AND MATERIALS



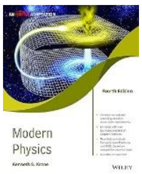
Name: Physics of Atoms and Molecules
Author: B. H. Bransden and C. J. Joachain
Edition: 2nd Ed.
Publisher: Pearson Education India
ISBN: 978-8177582796



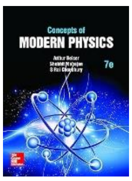
Name: The Physics of Atoms and Quanta: Introduction to Experiments and Theory
Author: Hermann Haken and Hans Christoph Wolf
Edition: 7th Ed.
Publisher: Springer-Verlag Berlin and Heidelberg GmbH & Co. K
ISBN: 978-3540208075



Name: Atomic and Laser Spectroscopy
Author: Alan Corney
Edition: 1976
Publisher: Oxford University Press
ISBN: 978-0199211456



Name: Modern Physics
Author: Kenneth S. Krane
Edition: 4th Ed.
Publisher: Wiley
ISBN: 978-9354244681



Name: Concepts of Modern Physics
Author: Arthur Beiser, Shobhit Mahajan and S. Rai Choudhury
Edition: 7th Ed.
Publisher: McGraw Hill Education
ISBN: 978-9351341857

8.0 MAPPING OF CLO TO PO AND PSO

The course outcomes and their mapping with program outcomes are specified in the table below

Course Learning Outcomes	Programme Outcomes (POs)												Programme Specific Outcome (PSOs)					
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CO3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

9.0 ASSESSMENT SCHEME

The evaluation system for this course consists of an 80% weightage on a comprehensive theory examination, which assesses students' understanding of various course topics, and a 20% weightage allocated to internal assessments, including internal examinations, assignments, class participation, and overall engagement in the course throughout the semester.

THEORY:

(A) Internal assessment: (20 marks): Continuous evaluation and internal assessment are implemented to foster and maintain a thorough understanding throughout the learning process. By regularly assessing comprehension through assignments, quizzes, and class participation, educators can address learning gaps promptly and support students in achieving deeper knowledge and proficiency in the subject matter.

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Section	Total Questions	Marks for each question	have to attempt	Total Marks
A	5	4	4	20
B	5	10	3	30
C	4	15	2	30

PRACTICUM:

(A) Internal assessment: (20 marks): In the internal assessment of the practicum components, the student's performance, understanding, skills, sincerity, and involvement in laboratory work during the entire semester are evaluated.

(B) End-term examination (80 marks): The ability to apply theoretical knowledge to real-world situations is the fundamental criterion used in the End Term examination. It typically involves students' activity on randomly assigned laboratory works and the Laboratory Report (Notebook) on the performed work in the entire semester. In the End examination, the student must complete randomly assigned tasks and prepare a report on their work, including appropriate conclusions. The mark distribution for the End term examination as follows.

Activity	Marks
Laboratory work in the Examination	40
Laboratory Notebook	20
Presentation/Viva-voce	20

PHY-001-CC-3230: NUCLEAR AND PARTICLE PHYSICS

NCrF Level: 5.5

Programme: Four Year Undergraduate Programme **Semester:** Sixth

Course Category: Major Course (Core Course)

Credit (L: T: P) 3: 1: 0

Credit Hours Lecture: 45 Hours, Tutorial: 15 Hours

1.0 COURSE LEARNING OBJECTIVES

The objective of the course is to teach fundamental understanding of the nucleus, their formation and properties. The Learning objectives of the course are:

- To introduce properties of nuclei and details of popular nuclear models. To derive and discuss properties of nuclear decays and nuclear reactions in brief.
- To familiarize with the fundamental forces and the dynamics of elementary particles under these forces
- To overview basic relativistic quantum mechanics and quantum electrodynamics for particle physics

2.0 COURSE LEARNING OUTCOME

After completing this course, students will be able to,

CO	Outcomes
CO1:	Understand and describe the general properties of atomic nuclei, including size, shape, binding energy, stability, spin, parity and their variation with mass number of the nucleus. .
CO2:	Explain the nature and characteristics of nuclear forces, including their role in binding nucleons within the nucleus and differentiating them from other fundamental forces.
CO3:	Learn the fundamentals of radioactivity, including types of decay, half-life and various theoretical formulations of nuclear disintegration like α decay, β decay and γ decays.
CO4:	Understand and compare various nuclear models, explain their significance in predicting and describing nuclear properties and behaviors.
CO5:	Able to explain the different types of nuclear reactions, such as fission, fusion, and scattering, and calculate the energy changes associated with these reactions.
CO6:	Understand the nature and origins of cosmic rays, including their composition, energy spectrum, and interactions with the Earth's atmosphere and magnetic field.
CO7:	Understand the principles of particle detection, including the operation, design, and applications of different types of particle detectors in experimental physics
CO8:	Learn the principles of particle acceleration, including the design, operation, and optimization of particle accelerators for various applications in research and industry.
CO9:	Get the knowledge of elementary particles as fundamental constituents of matter and their properties, conservation laws during interaction on the basis of the standard model.
CO10:	Get the basic understanding of the interaction of various nuclear radiation fundamental particles with matter in low and high energy.

3.0 SKILLS TO BE LEARNED

- perform complex calculations involving nuclear reactions, decay processes, and energy transformations, using mathematical models and principles.
- Use of theoretical models, experimental evidence, and scientific literature to analyze complex nuclear phenomena.

4.0 DETAILED CONTENTS OF THE COURSE: THEORY

Credit: 3 **Classroom Teaching: 45+15 Horus**

MODULE 1

General Properties of Nuclei: Constituents of nucleus and their Intrinsic properties, Shape and size quantitative facts about mass, radii, charge density (matter density), average binding energy and its variation with mass number, main features of binding energy curve, N/A plot, angular momentum, spin, parity, magnetic moment, electric moments, nuclear excited states. Nuclear forces - two nucleon systems-deuteron with potentials, n-p and p-p/n-n interactions at different energies, exchange forces and tensor forces Yukawa's hypothesis, meson theory of nuclear force. **[7+2 hours]**

Radioactivity: laws of radioactivity, radioactive dating, radioactive series, theory of alpha, beta & gamma decays and their properties, Alpha decay - theory of α-emission, Gamow factor, Geiger Nuttall law, α-decay spectroscopy, β -decay - energy kinematics for β decay, positron emission, electron capture, neutrino hypothesis, Gamma decay: Gamma rays' emission & kinematics, internal conversion. **[8+3 hours]**

MODULE 2

Nuclear Models: Liquid drop model approach, semi empirical mass formula and significance of its various terms, condition of nuclear stability, two nucleon separation energies, Fermi gas model (degenerate fermi gas, nuclear symmetry potential in Fermi gas), evidence for nuclear shell structure, nuclear magic numbers, basic assumption of shell model, concept of mean field, residual interaction, collective nuclear model; superconductivity model (qualitative idea only) **[7+3 hours]**

Nuclear Reactions: Types of Reactions, Conservation Laws, kinematics of reactions, Q-value, reaction rate, reaction cross section, Concept of compound and direct Reaction, resonance reaction, Coulomb scattering (Rutherford scattering), nuclear fission and fusion, nuclear reactors – homogeneous, heterogeneous and breeder reactor, Fission bomb and fusion bomb **[6+2 hours]**

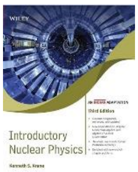
Cosmic Rays: primary and secondary cosmic rays, geomagnetic effect, Extensive air showers, origin of cosmic rays. **[2 hours]**

MODULE 3

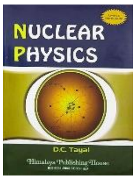
Particle detectors and accelerators: Interaction of Nuclear Radiation with matter, Energy loss due to ionization (Bethe-Block formula), energy loss of electrons, Cerenkov radiation. Ionization chamber, proportional counter, GM Counter, scintillation detectors, solid state detector Particle accelerators - linear accelerators, cyclotron, bevatron **[7+3 hours]**

Particle physics: Particle interactions in nature basic features, Broad classification of elementary particles, Symmetries and Conservation Laws: energy and momentum, angular momentum, parity, baryon number, Lepton number, Isospin, Strangeness and charm, Gell-Mann-Nishijima scheme, CPT conservation, quark hypothesis, color quantum number and gluons. **[8+2 hours]**

5.0 TEXT BOOKS

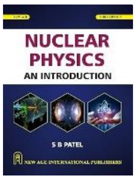


Name: Introductory Nuclear Physics
Author: Kenneth S. Krane
Edition: 3rd Ed. (2022)
Publisher: Wiley
ISBN: 978-9354640834

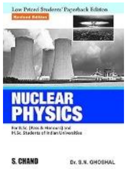


Name: Nuclear Physics
Author: D. C. Tayal
Edition:
Publisher: Himalaya Publishing Hourse
ISBN: 978-9350978306

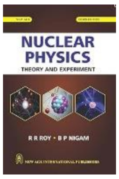
6.0 REFERENCE BOOKS AND MATERIALS



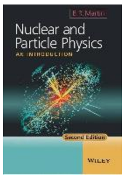
Name: Nuclear Physics: An Introduction
Author: S B Patel
Edition: 3rd Ed.
Publisher: New Age International Private Limited
ISBN: 978-8122472417



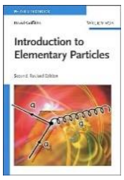
Name: Nuclear Physics
Author: S. N. Ghosal
Edition:
Publisher: S. Chand
ISBN: 978-9352837274



Name: Nuclear Physics: Theory and Experiments
Author: R. R. Roy; B. P. Nigam
Edition: 3rd Ed.
Publisher: New Age International Private Limited
ISBN: 978-8122449884



Name: Nuclear and Particle Physics
Author: B.R. Martin
Edition: 2nd Ed.
Publisher: Wiley
ISBN: 978-8126565078



Name: Introduction to Elementary Particles
Author: David J. Griffiths
Edition: 2nd Ed.
Publisher: Wiley-VCH
ISBN: 978-3527406012

7.0 MAPPING OF COURSE LEARNING OUTCOME TO PROGRAMME LEARNING OUTCOME

The course outcomes and their mapping with program outcomes is specified in the table below

Course Learning Outcomes	Program Outcomes (POs)												Program Specific Outcome (PSOs)					
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6
CO1																		
CO2																		
CO3																		
CO4																		
CO5																		
CO6																		
CO7																		
CO8																		
CO9	H																	

8.0 ASSESSMENT SCHEME

The evaluation system for this course consists of an 80% weightage on a comprehensive theory examination, which assesses students' understanding of various course topics, and a 20% weightage allocated to internal assessments, including internal examinations, assignments, class participation, and overall engagement in the course throughout the semester.

THEORY:

(A) Internal assessment: (20 marks): Continuous evaluation and internal assessment are implemented to foster and maintain a thorough understanding throughout the learning process. By regularly assessing comprehension through assignments, quizzes, and class participation, educators can address learning gaps promptly and support students in achieving deeper knowledge and proficiency in the subject matter.

(B) End-term examination (80 marks): The end-term examination serves as a culmination of students' learning in the course, assessing their comprehensive understanding and proficiency in various topics in the course. It provides a structured platform for students to demonstrate their knowledge, problem-solving abilities, and application of theoretical concepts, ultimately gauging their readiness to progress. Pattern of End term question paper

Section	Total Questions	Marks for each question	have to attempt	Total Marks
A	5	4	4	20
B	5	10	3	30
C	4	15	2	30

PHY-001-CC-3240: CONDENSED MATTER PHYSICS

NCrF Level:	5.5	
Programme:	Four Year Undergraduate Programme	**Semester:** Sixth
Course Category:	Major Course (Core Course)	
Credit (L: T: P)	3: 0: 2	
Credit Hours	Theory: 45 Hours, Practicum: 60 Hours	

1.0 COURSE LEARNING OBJECTIVES

The emphasis of course is to equip students with understanding of the fundamental principles and concepts that govern the behavior of condensed matter. The Learning objectives of the courses are

- Equip students with the ability to understand crystal structures, analyze their physical properties, and apply crystallographic methods
- Develop an understanding of lattice vibrations' theory and their impact on thermal conductivity and specific heat in materials,
- Develop a comprehensive understanding of the principles governing magnetic and dielectric behaviors in materials and their applications.
- Equip students with the ability to comprehend and apply free electron theory and band theory to analyze the electronic properties of materials.
- Develop a deep understanding of the theory, phenomena, and applications of superconductivity,

2.0 COURSE LEARNING OUTCOME

After completing this course, students will be able to,

CO	Outcomes
CO1:	Learn about the basics crystal structures and their classification on the basics of symmetry elements, lattice types, and coordination environments.
CO2:	Learn the principles used to explain diffraction in crystalline material and the techniques used to study a crystalline system using X-ray.
CO3:	Get the knowledge of lattice vibrations and phonons' role in material thermal behavior, which enable them to analyze thermal properties of materials for specific applications.
CO4:	Get a basic understanding about magnetisation, magnetic susceptibility , magnetic ordering and the principles behind the diverse magnetic interactions in materials.
CO5:	Get a comprehensive understanding of dielectric materials and their properties, including permittivity, polarization, and dielectric loss and their applications.
CO6:	Learn basics of electrical conductivity in material and to analyze the behaviour of free electrons in materials on the Fermi gas model to analyze energy distribution and fermi energy.
CO7:	Gain a comprehensive understanding of band theory and its use to describe electronic properties of material under different circumstances.
CO8:	Learn the basics of superconductivity and the underlying model proposed behind the different characteristics of conducting material, and their application in various domains.
CO9:	Learn to apply theoretical concepts to design and execute experiments, analyze data, and draw meaningful conclusions about the properties and behaviours of condensed matter systems.
CO10:	Able to prepare clear, structured, and concise scientific reports, effectively presenting laboratory works and findings with enhanced clarity.

3.0 SKILLS TO BE LEARNED

- To analyze the properties of materials by exploring the band formation in solids.
- To distinguish materials in terms of their magnetic behaviors.
- To analyze the dependence of dielectric properties of material aon polarization and frequency.

4.0 DETAILED CONTENTS OF THE COURSE: THEORY

Credit: 3 **Classroom Teaching: 45 Horus**

MODULE 1

Crystal Structure: Amorphous and Crystalline Materials, Lattice and Basis, Unit Cell, Lattice Translation Vectors, crystal systems - Bravais lattices, crystal planes and Miller indices, Close packed structures – packing fraction, SC, BCC, FCC and HCP, rock salt structure, Diamond structure, Zinc Blende structure, perovskite structure. Crystal structure determination - electron and neutron diffraction, x-ray and X-ray spectra, Auger effect, Moseley law, X-ray diffraction in crystal -methods, Bragg's Law, Ewald construction, Atomic and Geometrical Factor. Structure factor Reciprocal Lattice - Brillouin Zones, Bragg's Law in reciprocal lattice. Bonding in crystal - cohesive energy, Defects in crystals: Point defects (Frenkel & Schottky), line defects, **[9 hours]**

Lattice Vibrations and Thermal Properties: Classical theory of Specific heat, Einstein and Debye models of specific heat. continuum lattice, Vibration of lattice with monoatomic and diatomic one-dimensional lattice: Dispersion relation, optical and acoustical branches. Quantization of elastic waves: Phonon, Average energy of harmonic oscillator, boundary condition, evaluation of quantized lattice vibration **[6 hours]**

MODULE 2

Magnetic Properties: Diamagnetic, paramagnetic and ferromagnetic materials, temperature dependence, Origin of magnetism - Langevin Theory of diamagnetism, Langevin's Theory Paramagnetism, Quantum Mechanical Treatment of Paramagnetism, Curie's law, Ferromagnetism, Weiss's Theory of Ferromagnetism and Ferromagnetic Domains. anti-ferromagnetism, ferrimagnetism, magnetic hysteresis – Hard magnet and soft magnet and their applications, coercive force and Energy Loss **[9 hours]**

Dielectric Properties: Polarization. Local Electric Field at an Atom. Depolarization Field. Electric Classical Theory of Electric Polarizability, Polarizability, Susceptibility. Sources of polarization – ionic, electronic, orientational, space charge polarization, temperature dependence of orientational polarization, Langevin-Debye equation, Clausius-Mossotti Equation. Dialectic loss - Complex Dielectric Constant. Ferroelectricity, PE hysteresis loop, Curie-Weiss Law , Piezoelectric effect, Pyroelectric effect, **[6 hours]**

MODULE 3

Electrical Conductivity and Free Electron Fermi gas: Drude-Lorentz theory, thermal conductivity, Free electron gas in three-dimension, Wiedemann-Franz law, Quantum Free electron theory – fermi surface, density of state, Applications of quantum free electron theory - Heat capacity and Paramagnetism, ohm's law. **[4 hours]**

Elementary band theory: Formation of energy band in solid due to overlapping of atomic energy levels, Periodic potential in a crystal, Bloch Theorem, Kronig-Penney Model (1 dimensional approach only) – evaluation of energy band, Reduced zone and extended zone, Effective mass, variation of electron velocity and effective mass in reduced zone, concept of hole - heavy hole and light hole, energy bands in insulator, metal and semiconductor, Magneto-resistance and Hall effect **[7 hours]**

Superconductivity: critical temperature, Critical magnetic field. Meissner effect. Type I and type II superconductors, Isotope effect, energy gap, London equation - penetration depth, BCS theory of superconductivity, Coherence length, Josephson junction, SQUID **[4 hours]**

5.0 DETAILED CONTENTS OF THE COURSE: PRACTICUM

Credit: 2 **Laboratory Work: 60 Hours**

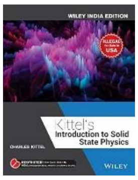
In the practicum component of the course, students will undergo experiment related to different phenomena of condensed matter physics. Through a series of practical exercises, students will learn to draw various curves, analyze their properties, and understand their applications. It emphasizes the importance of accuracy in graphical representation to visualize and interpret physical phenomena. In the second part students have to go through some exercise on numerical computation manually as well as spreadsheet applications.

Students are required to conduct experiments from the provided list, meticulously following the suggested procedures and protocols outlined for each. Subsequently, they must compile comprehensive reports for every experiment, adhering to scientific standards and conventions. These reports should encompass a detailed description of the experimental setup and methodology employed, including any modifications made during the course of the experiment. Furthermore, students are expected to record and analyze their experimental data systematically, drawing upon relevant theoretical concepts and principles to interpret their findings accurately. Additionally, the reports should include a thorough discussion of the results obtained, highlighting any observed trends, anomalies, or correlations, and offering insightful explanations or hypotheses where applicable. Moreover, students must demonstrate proficiency in presenting their results graphically, utilizing tables, figures, and diagrams to enhance clarity and facilitate comprehension. Finally, each report should conclude with a succinct summary of the key findings and conclusions drawn from the experiment, along with any recommendations for further investigation or improvement.

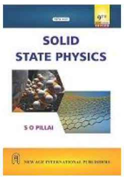
The teacher has the flexibility to introduce a wide range of laboratory experiments that directly correlate with and reinforce the theoretical concepts covered in the course curriculum. These experiments serve as practical applications of the theoretical principles discussed in lectures.

1. To measure susceptibility of paramagnetic solution (Quinck`s Tube Method)
2. To measure the Magnetic susceptibility of Solids.
3. To determine the Coupling Coefficient of a Piezoelectric crystal.
4. To measure the Dielectric Constant of a dielectric Materials with frequency
5. To determine the complex dielectric constant and plasma frequency of metal using Surface Plasmon resonance (SPR)
6. To determine the refractive index of a dielectric layer using SPR
7. To study the PE Hysteresis loop of a Ferroelectric Crystal.
8. To draw the BH curve of Fe using Solenoid & determine energy loss from Hysteresis.
9. To measure the resistivity of a semiconductor (Ge) with temperature by four-probe method (room temperature to 150 oC) and to determine its band gap.
10. To determine the Hall coefficient of a semiconductor sample.
11. Study of Electron spin resonance- determine magnetic field as a function of the resonance frequency
12. Study of Zeeman effect: with external magnetic field; Hyperfine splitting
13. To show the tunneling effect in tunnel diode using I-V characteristics.
14. Quantum efficiency of CCDs

6.0 TEXT BOOKS

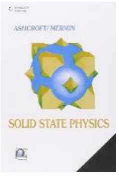


Name: Introduction to Solid State Physics
Author: Charles Kittel
Edition: 2019
Publisher: Wiley
ISBN: 978-8126578436

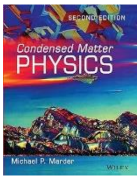


Name: Solid State Physics
Author: S. O. Pilai
Edition: 9th Ed.
Publisher: NEW AGE International
ISBN: 978-9389802313

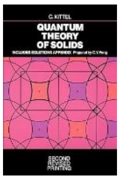
7.0 REFERENCE BOOKS AND MATERIALS



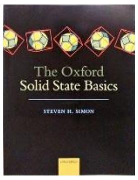
Name: Solid State Physics
Author: Neil W. Ashcroft and N. David Mermin
Edition: 1st Ed.
Publisher: Cengage
ISBN: 978-8131500521



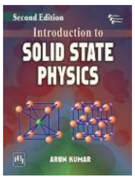
Name: Condensed Matter Physics
Author: Michael P. Marder
Edition: 2nd Ed.
Publisher: Wiley
ISBN: 978-8126565054



Name: Quantum Theory of Solid
Author: Charles Kittel
Edition: 2nd Ed.
Publisher: Wiley
ISBN: 978-0471624127



Name: The Oxford Solid State Basics
Author: Steven H. Simon
Edition: 2nd Ed.
Publisher: Oxford University Press
ISBN: 978-0199680771



Name: Indroduction to Solid State Physics
Author: Arun Kumar
Edition: 2nd Ed.
Publisher: PHI Learning
ISBN: 978-8120351479

6.0 MAPPING OF CLO TO PO AND PSO

The course outcomes and their mapping with program outcomes are specified in the table below

Course Learning Outcomes	Programme Outcomes (POs)												Programme Specific Outcome (PSOs)					
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6
CO1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

9.0 ASSESSMENT SCHEME

The evaluation system for this course consists of an 80% weightage on a comprehensive theory examination, which assesses students' understanding of various course topics, and a 20% weightage allocated to internal assessments, including internal examinations, assignments, class participation, and overall engagement in the course throughout the semester.

THEORY:

(A) Internal assessment: (20 marks): Continuous evaluation and internal assessment are implemented to foster and maintain a thorough understanding throughout the learning process. By regularly assessing comprehension through assignments, quizzes, and class participation, educators can address learning gaps promptly and support students in achieving deeper knowledge and proficiency in the subject matter.

(B) End-term examination (80 marks): The end-term examination serves as a culmination of students' learning in the course, assessing their comprehensive understanding and proficiency in various topics in the course. It provides a structured platform for students to demonstrate their knowledge, problem-solving abilities, and application of theoretical concepts, ultimately gauging their readiness to progress. Pattern of End term question paper

Section	Total Questions	Marks for each question	have to attempt	Total Marks
A	5	4	4	20
B	5	10	3	30
C	4	15	2	30

PRACTICUM:

(A) Internal assessment: (20 marks): In the internal assessment of the practicum components, the student's performance, understanding, skills, sincerity, and involvement in laboratory work during the entire semester are evaluated.

(B) End-term examination (80 marks): The ability to apply theoretical knowledge to real-world situations is the fundamental criterion used in the End Term examination. It typically involves students' activity on randomly assigned laboratory works and the Laboratory Report (Notebook) on the performed work in the entire semester. In the End examination, the student must complete randomly assigned tasks and prepare a report on their work, including appropriate conclusions. The mark distribution for the End term examination as follows.

Activity	Marks
Laboratory work in the Examination	40
Laboratory Notebook	20
Presentation/Viva-voce	30

PHY-001-CC-4110: ELECTRODYNAMICS

NCrF Level:	6.0		
Programme:	Four Year Undergraduate Programme	**Semester:**	Seventh
Course Category:	Major Course (Core Course)		
Credit (L: T: P)	3: 0: 1		
Credit Hours	Theory: 45 Hours, Practicum: 30 Hours		

1.0 COURSE LEARNING OBJECTIVES

The course aims to enable students to master the principles of electrodynamics, apply advanced mathematical techniques, develop analytical and computational problem-solving skills, and understand practical applications in diverse fields. The Learning Objectives of the course are:

- Apply Maxwell's equations to describe the behavior of electric and magnetic fields in various contexts.
- Develop proficiency in vector calculus to solve electromagnetic problems,
- to analyze electromagnetic phenomena using theoretical frameworks and mathematical models.
- Utilize computational methods, including numerical simulations and software tools, to solve complex electrodynamics problems.

2.0 COURSE LEARNING OUTCOME

After completing this course, students will be able to,

CO	Outcomes
CO1:	Understand the fundamental principles of orbital and spin angular momentum, angular momentum operator, commutation relations and eigen equations.
CO2:	Lean to apply techniques for the addition of angular momenta to solve problems involving composite systems using angular momentum operator and Clebsch-Gordon coefficient
CO3:	Learn the concept and mathematical framework of time-independent and time-dependent perturbation theory to solve for energy shifts and state modifications in quantum systems.
CO4:	Understand the principles and mathematical framework of the variational method and its use to approximate ground state energies and wave functions of quantum systems.
CO5:	Understand the principles behind the WKB (Wentzel-Kramers-Brillouin) approximation and to apply in solving Schrödinger equation in the semiclassical limit for various potential problems.
CO6:	Understand the behaviour of identical particles in a quantum system and learn to analyze the implications of particle indistinguishability on wave functions, and physical observables.
CO7:	Learn the basics of scattering theory to describe and predict the outcomes of various scattering experiments, including elastic, inelastic, and resonant scattering phenomena.
CO8:	Understand the principles of relativistic quantum mechanics, including Lorentz invariance and the Dirac equation and their use to analyze particle behaviour in relativistic regimes.
CO9:	Able to prepare clear, structured, and concise scientific reports, effectively presenting about the performed exercise in the laboratory.
CO10:	Understand the fundamental principles of orbital and spin angular momentum, angular momentum operator, commutation relations and eigen equations.

3.0 SKILLS TO BE LEARNED

- to analyze and solve problems using Maxwell's equations, including understanding the behavior of electric and magnetic fields in different scenarios.
- Gain proficiency in applying advanced mathematical techniques such as vector calculus and differential equations to model and solve electromagnetic problems.
- Learn how to apply electrodynamics principles to design and analyze practical systems and devices, such as antennas, transmission lines, and electromagnetic wave propagation in various media.

4.0 DETAILED CONTENTS OF THE COURSE: THEORY

Credit: 3 **Classroom Teaching: 45 Horus**

MODULE 1

Boundary Value Problems in Electrostatics: The first and second uniqueness theorems. Solutions of Laplace's and Poisson equations in one dimension using spherical and cylindrical coordinate systems and solutions in three-dimensional using Cartesian coordinate systems. Electrostatic boundary conditions for conductors and capacitors **[7 hours]**

Multipole Expansion: Monopole and dipole and quadrupole potentials at large distances due to an arbitrary charge distribution expressed in terms of Legendre polynomials, negative Gradient of Dipole potential in spherical coordinates. Force and Torque on a dipole. **[4 hours]**

Electric Field in Matter: Polarization in matter, Bound charges and their physical interpretation. Field inside a dielectric, Displacement vector D, Gauss' Law in the presence of dielectrics, Boundary conditions for D, Linear dielectrics, Electric Susceptibility and Dielectric Constant, idea of complex dielectric constant due to varying electric field. Boundary value problems with linear dielectrics. **[3 hours]**

MODULE 2

Maxwell's equations. Displacement Current. Vector and Scalar Potentials. Gauge Transformations: Lorentz and Coulomb Gauge. Boundary Conditions at Interface between Different Media. Wave Equations. Plane Waves in Dielectric Media. Poynting Theorem and Poynting Vector. Electromagnetic (EM) Energy Density. Physical Concept of Electromagnetic Field Energy Density, Momentum Density and Angular Momentum Density. **[5 hours]**

EM Wave Propagation in Unbounded Media: Plane EM waves through vacuum and isotropic dielectric medium, refractive index and dielectric constant, wave impedance. Propagation through conducting media, relaxation time, skin depth. **[3 hours]**

EM Wave in Bounded Media: Boundary conditions at a plane interface between two media. Reflection & refraction of plane waves at plane interface between two dielectric media-Laws of Reflection & Refraction. Fresnel's Formula for perpendicular & parallel polarization cases, Brewster's law. Reflection & Transmission coefficients. Total internal reflection, **[7 hours]**

MODULE 3

Polarization of Electromagnetic Waves: Description of Linear, Circular and Elliptical Polarization. Propagation of E.M. Waves in Anisotropic Media. Symmetric Nature of Dielectric Tensor. Fresnel's Formula. Uniaxial and Biaxial Crystals. Light Propagation in Uniaxial Crystal. Double Refraction. Polarization by Double Refraction. Nicol Prism. Ordinary & extraordinary refractive indices. Production & detection of Plane, Circularly and Elliptically Polarized Light. Phase Retardation Plates: Quarter-Wave and Half-Wave Plates. Babinet Compensator and its Uses. Analysis of Polarized Light **[7 hours]**

Rotatory Polarization: Optical Rotation. Biot's Laws for Rotatory Polarization. Fresnel's Theory of optical rotation. Calculation of angle of rotation. Experimental verification of Fresnel's theory. Specific rotation. Laurent's half-shade polarimeter**. [3 hours]**

Wave Guides: Planar optical waveguides. Planar dielectric waveguide. Condition of continuity at interface. Phase shift on total reflection. Eigenvalue equations. Phase and group velocity of guided waves. Field energy and Power transmission. **[5 hours]**

5.0 DETAILED CONTENTS OF THE COURSE: PRACTICUM

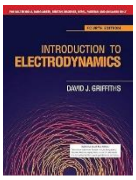
Credit: 2 **Laboratory Work: 60 Hours**

In the practicum component of the course, students will undergo hands-on experience related to different phenomena of electromagnetic theory as well as simulation of principle of electrodynamics using Python

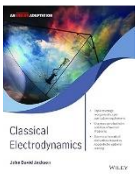
Suggested List of Experiments:

1) To verify the law of Malus for plane polarized light.
2) To determine the specific rotation of sugar solution using Polarimeter.
3) To analyze elliptically polarized Light by using a Babinet's compensator.
4) To study Birefringence effect by analyzing the change in polarization state through crossed polarizers.
5) To study birefringence induced by mechanical stress in transparent materials using crossed polarizers.
6) To study Faraday effect and measure the Verdet constant.
7) To study dependence of radiation on angle for a simple Dipole antenna.
8) To determine the wavelength and velocity of ultrasonic waves in a liquid (Kerosene Oil, Xylene, etc.) by studying the diffraction through ultrasonic grating.
9) To study the reflection, refraction of microwaves
10) To study Polarization and double slit interference in microwaves.
11) To determine the refractive index of liquid by total internal reflection using Wollaston's air-film.
12) To determine the refractive Index of (1) glass and (2) a liquid by total internal reflection using a Gaussian eyepiece.
13) To study the polarization of light by reflection and determine the polarizing angle for air-glass interface.
14) To study different principle to electromagnetic using python
15) Electromagnetic Simulations using FDTD, FEM, MoM

6.0 TEXT BOOKS

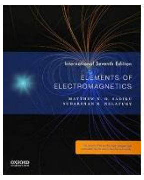


Name: Introduction to Electrodynamics
Author: David J. Griffiths
Edition: 4th Ed. (2020)
Publisher: Cambridge University Press
ISBN: 978-1108822909

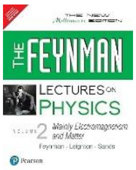


Name: Classical Electrodynamics
Author: John David Jackson
Edition: 2020
Publisher: Wiley
ISBN: 978-9388991070

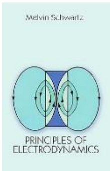
7.0 EFERENCE BOOKS AND MATERIALS



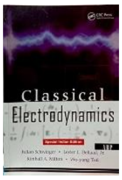
Name: Elements of Electromagnetics
Author M.N.O. Sadiku
Edition: 7th Ed.
Publisher: Oxford University Press.
ISBN: 978-0190698621



Name: The Feynman Lectures On Physics: Vol-2
Author: Feynman, Leighton, Sands
Edition: 2012
Publisher: Pearson
ISBN: 978-8131792124



Name: Principles of Electrodynamics
Author: Melvin Schwartz
Edition: 2003
Publisher: Dover Publications Inc.
ISBN: 978-0486654935



Name: Principles of Electrodynamics
Author: J. Schwinger, L. L. DeRaad, K.A. Milton, Wu-yang Tsi
Edition: 1998
Publisher: Taylor & Francis
ISBN: 978-1138329416

8.0 MAPPING OF CLO TO PO AND PSO

The course outcomes and their mapping with program outcomes are specified in the table below

Course Learning Outcomes	Programme Outcomes (POs)												Programme Specific Outcome (PSOs)					
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6
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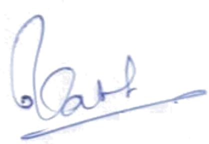
CO2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-



9.0 ASSESSMENT SCHEME

The evaluation system for this course consists of an 80% weightage on a comprehensive theory examination, which assesses students' understanding of various course topics, and a 20% weightage allocated to internal assessments, including internal examinations, assignments, class participation, and overall engagement in the course throughout the semester.

THEORY:

(A) Internal assessment: (20 marks): Continuous evaluation and internal assessment are implemented to foster and maintain a thorough understanding throughout the learning process. By regularly assessing comprehension through assignments, quizzes, and class participation, educators can address learning gaps promptly and support students in achieving deeper knowledge and proficiency in the subject matter.

(B) End-term examination (80 marks): The end-term examination serves as a culmination of students' learning in the course, assessing their comprehensive understanding and proficiency in various topics in the course. It provides a structured platform for students to demonstrate their knowledge, problem-solving abilities, and application of theoretical concepts, ultimately gauging their readiness to progress. Pattern of End term question paper

Section	Total Questions	Marks for each question	have to attempt	Total Marks
A	5	4	4	20
B	5	10	3	30
C	4	15	2	30

PRACTICUM:

(A) Internal assessment: (20 marks): In the internal assessment of the practicum components, the student's performance, understanding, skills, sincerity, and involvement in laboratory work during the entire semester are evaluated.

(B) End-term examination (80 marks): The ability to apply theoretical knowledge to real-world situations is the fundamental criterion used in the End Term examination. It typically involves students' activity on randomly assigned laboratory works and the Laboratory Report (Notebook) on the performed work in the entire semester. In the End examination, the student must complete randomly assigned tasks and prepare a report on their work, including appropriate conclusions. The mark distribution for the End term examination as follows.

Activity	Marks
Laboratory work in the Examination	40
Laboratory Notebook	20
Presentation/Viva-voce	20

PHY-001-CC-4120: APPLICATIONS OF QUANTUM MECHANICS

NCrF Level:	6.0		
Programme:	Four Year Undergraduate Programme	**Semester:**	Seventh
Course Category:	Major Course (Core Course)		
Credit (L: T: P)	3: 0: 1		
Credit Hours	Theory: 45 Hours, Practicum: 30 Hours		

1.0 COURSE LEARNING OBJECTIVES

This core course is an intensive exploration about the applications of quantum mechanics in various branches of physics. It provides a comprehensive understanding and practical skills in various advanced topics within quantum mechanics, preparing students for both theoretical study and practical applications in research and technology. The Learning Objectives of this course are:

- Understand and apply the principles of angular momentum to explain various phenomena of physics.
- To learn various approximation methods in quantum mechanics, including perturbation theory, variational methods, and the WKB approximation, to solve complex problems and analyze physical systems effectively.
- To Understand the principles governing the quantum mechanics of identical particles, including fermions and bosons, and apply these principles to systems such as atoms, nuclei, and quantum gases.
- Explore scattering theory in quantum mechanics, including the concept of cross-sections, scattering amplitudes, and the relationship between the scattering potential and observable quantities.
- Introduce concepts and techniques of relativistic quantum mechanics, including the Dirac equation, spinors, and applications in particle physics and quantum field theory.

2.0 COURSE LEARNING OUTCOME

After completing this course, students will be able to,

CO	Outcomes
CO1:	Understand the fundamental principles of orbital and spin angular momentum, angular momentum operator, commutation relations and eigen value equation.
CO2:	Lean to apply techniques for the addition of angular momenta to solve problems involving composite systems using angular momentum operator and Clebsch-Gordon coefficient
CO3:	Learn the concept and mathematical framework of time-independent and time-dependent perturbation theory to solve for energy shifts and state modifications in quantum systems.
CO4:	Understand the principles and mathematical framework of the variational method and its use to approximate ground state energies and wave functions of quantum systems.
CO5:	Understand the principles behind the WKB (Wentzel-Kramers-Brillouin) approximation and to apply in solving Schrödinger equation in the semiclassical limit for various potential problems.
CO6:	Understand the behaviour of identical particles in quantum system and learn to analyse the implications of particle indistinguishability on wave functions, and physical observables.
CO7:	Learn the basics of scattering theory to describe and predict the outcomes of various scattering experiments, including elastic, inelastic, and resonant scattering phenomena.
CO8:	Understand the principles of relativistic quantum mechanics, including Lorentz invariance and the Dirac equation and their use to analyse particle behaviour in relativistic regimes.
CO9:	Able to prepare clear, structured, and concise scientific reports, effectively presenting about the performed exercise in the laboratory.

3.0 SKILLS TO BE LEARNED

- To explain various atomic and molecular phenomenon
- To solve complex Schrodinger equations using approximation methods.

4.0 DETAILED CONTENTS OF THE COURSE: THEORY

Credit: 3 **Classroom Teaching: 45 Horus**

MODULE 1

Theory of Angular Momentum: General formalism of angular momentum, derivation of eigen values and eigen functions of and , commutation relations, representation of angular momentum operator by matrices, Addition of angular momentum – CG coefficients, Ladder operates, spin angular momentum, Pauli spin matrices, Total angular momentum - LS coupling and jj coupling, Hund's rule, eigen value and eigen function of and their matrix form, Addition of total angular momentum, recursion relation. Evaluation and calculation of Clebsch Gordan coefficients. **[9 hours]**

Perturbation Theory: Time-independent perturbation theory: non-degenerate and degenerate cases and applications, Ground state energy of helium, applications of time independent perturbation theory; Time-dependent perturbation theory - Perturbation series and transition probabilities, Fermi's golden rule, Applications in atomic and molecular physics **[6 hours]**

MODULE 2

Variational Method: Linear variational function (Rayleigh Ritz method), Applications – Ground state energy of H_2 and He atom. Van der wall's interaction between two Hydrogen-like atoms. bound states, the Yukawa potential, the virial theorem; excited states. **[5 hours]**

WKB approximation: The principle of the WKB approximation method, WKB wave functions, validity of WKB approximation, the turning point and connection formula, Applications – barrier penetration, potential, well, adiabatic and sudden approximations- electric dipole selection rules, WKB, Semi-classical expansion, Linear potentials and the Airy function, Bohr-Sommerfeld quantisation, Tunnelling; The Sudden approximation, Quantum quenches; The Adiabatic approximation; Berry phase; The Born-Oppenheimer approximation, Molecular binding. **[6 hours]**

Identical Particle: Symmetric and anti-symmetric wave functions, Indistinguishability and its implications, Symmetric and anti-symmetric of wave functions, Exchange symmetry and exchange interactions, Physical consequences of exchange symmetry, collision of identical particles, spin and space wave functions for many-electron system, Identical particle in condensed matter physics **[4 hours]**

MODULE 3

Scattering Theory: Scattering in one dimension, reflection and transmission coefficients, S-matrix, bound states, resonances; Scattering in three dimensions, the cross-section, the scattering amplitude, partial waves, phase shifts and the optical theorem, a hard sphere, bound states and resonances again; the Lippmann-Schwinger equation, the Born approximation, Yukawa and Coulomb potentials, the Born expansion; Rutherford scattering, the hydrogen atom; Scattering off a lattice, Bragg condition, structure factor, Debye-Waller factor. **[8 hours]**

Relativistic Quantum Mechanics: Klein-Gordon equation – interpretation, properties and solutions, Application to scalar particles, Spinors - Lorentz boosts and spin transformations, particle in a coulomb field, Formulation of the Dirac equation - Solutions and properties of the Dirac equation, Spinors in the Dirac representation, Dirac equation for free particle, covariant form of Dirac equation, Dirac matrices, Physical interpretation of the Dirac equation- Prediction of the positron, Relativistic corrections and fine structure spin of Dirac particles, Basics of quantum Field theory and quantum electrodynamics **[7 hours]**

5.0 DETAILED CONTENTS OF THE COURSE: PRACTICUM

Credit: 2 **Laboratory Work: 60 Hours**

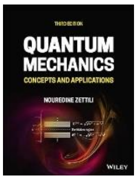
In the practicum component of the course, students will undergo exercise related visualization of quantum mechanical phenomena as well as to solve problems using Python.

a) Visualizing wave functions and probability densities
b) Representing quantum states and operators using NumPy
c) Solving the Schrödinger equation using finite difference methods
d) Implementing time evolution using Crank-Nicolson method
e) Simulating quantum tunneling
f) Calculating expectation values and uncertainties
g) Visualizing uncertainty relations
h) Visualizing uncertainty relations

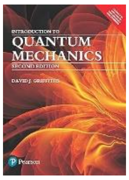
Using computational techniques solve the following problems based on quantum mechanics

1. Solve the s-wave Schrodinger equation for the ground state and the first excited state of the hydrogen atom
   a. $\frac{d^2y}{dt^2} = A(r), u(r), \quad A(r) = \frac{2m}{\hbar^2}[V(r) - E] \quad$ where $V(r) = -\frac{e^2}{r}$Where $m \rightarrow$ is the reduced mass of the electron
   b. Obtain the energy eigenvalues and plot the corresponding wavefunctions. Remember that the ground state energy of the hydrogen atom is ≈ 13.6 eV. Take $e = 3.795\ (\mathrm{eV\mathring{A}})^{1/2}$, $\hbar c = 1973\ (\mathrm{eV\mathring{A}})$ and $m = 0.511 \times 10^6\ \mathrm{eV/c^2}$
2. Solve the s-wave radial Schrodinger equation for an atom:
   a. $\frac{d^2y}{dt^2} = A(r), u(r), \quad A(r) = \frac{2m}{\hbar^2}[V(r) - E]$
   b. Where, m is the reduced mass of the system (which can be chosen to be the mass of an electron), for the screened coulomb potential
   c. $V(r) = -\frac{e^2}{r}e^{-\frac{r}{a}}$
   d. Find the energy (ineV)of the ground state of the atom to an accuracy of three significant digits. Also, plot thecorrespondingwavefunction. Take $m = 0.511 \times 10^6\ \mathrm{eV/c^2}$, $e = 3.795\ (\mathrm{eV\mathring{A}})$ and $a = 3\mathring{A}$, $5\mathring{A}$, $7\mathring{A}$. In these units $\hbar c = 1973\ (\mathrm{eV\mathring{A}})$. The ground state energy is expected to be above -12 eV in all three cases.
3. Solve the $s -$ wave radial Schrodinger equation for a particle of mass m
   a. $\boldsymbol{\frac{d^2y}{dt^2} = A(r), u(r), \quad A(r) = \frac{2m}{\hbar^2}[V(r) - E]}$
      i. For a harmonic oscillator potential
   b. $V(r) = \frac{1}{2}kr^2 + \frac{1}{3}br^3$
   c. For the ground state energy $(inMeV)$ of particle to an accuracy of three significant digits. Also, plot the corresponding wave function. Choose $m = 940\ MeV/c^2$, $k = 100\ MeVfm^{-2}, b = 0,\ 10,\ 30\ \ MeVfm^{-3}$. In these units $c\hbar = 197.3\ MeVfm$. The ground state energy is accepted to lie between 90 and 110 MeV for all three cases.

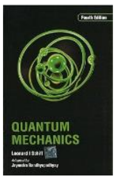
6.0 TEXT BOOKS



Name: Quantum Mechanics Concepts and Applications
Author: Nouredine Zettili
Edition: 3^{rd} Ed.
Publisher: Wiley
ISBN: 978-1118307892

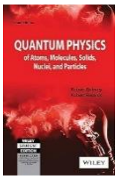


Name: Introduction to Quantum Mechanics
Author: D.J. Griffith
Edition: 2^{nd} Ed.
Publisher: Pearson Education
ISBN: 978-9332542891

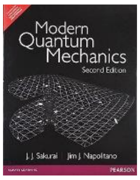


Name: Quantum Mechanics
Author: Leonard I. Schiff and Jayendra Bandyopadhyay
Edition: 3rd Edn. 2010
Publisher: Tata McGraw Hill
ISBN: 978-1259062865

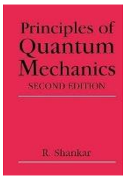
7.0 REFERENCE BOOKS AND MATERIALS



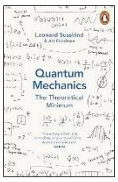
Name: Quantum Physics of Atoms, Molecules, Solids, Nuclei and Particles
Author: Robert Eisberg and Robert Resnick
Edition: 2nd Edn., 2002
Publisher: Wiley
ISBN: 978-8126508181



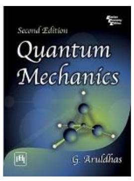
Name: Modern Quantum Mechanics
Author: J. J. Sakurai and Jim Napolitano
Edition: 2^{nd} Ed.
Publisher: Pearson Education India
ISBN: 978-9332519008



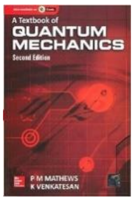
Name: Principles of Quantum Mechanics
Author: R. Shankar
Edition: 2^{nd} Ed. (2014)
Publisher: Springer
ISBN: 978-0306447907



Name: Quantum Mechanics: The Theoretical Minimum
Author: Leonard Susskind and Art Friedman
Edition: 2015
Publisher: Penguin Books Ltd
ISBN: 978-0141977812



Name: Quantum Mechanics
Author: G. Aruldhas
Edition: 2nd Edn. 2002
Publisher: PHI Learning of India
ISBN: 978-8120336353



Name: A Text book of Quantum Mechanics
Author: P.M.Mathews and K.Venkatesan
Edition: 2nd Ed., 2010
Publisher: McGraw Hill Education
ISBN: 978-0070146174

8.0 MAPPING OF CLO TO PO AND PSO

The course outcomes and their mapping with program outcomes are specified in the table below

Course Learning Outcomes	Programme Outcomes (POs)												Programme Specific Outcome (PSOs)					
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6
CO1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

9.0 ASSESSMENT SCHEME

The evaluation system for this course consists of an 80% weightage on a comprehensive theory examination, which assesses students' understanding of various course topics, and a 20% weightage allocated to internal assessments, including internal examinations, assignments, class participation, and overall engagement in the course throughout the semester.

THEORY:

(A) Internal assessment: (20 marks): Continuous evaluation and internal assessment are implemented to foster and maintain a thorough understanding throughout the learning process. By regularly assessing comprehension through assignments, quizzes, and class participation, educators can address learning gaps promptly and support students in achieving deeper knowledge and proficiency in the subject matter.

(B) End-term examination (80 marks): The end-term examination serves as a culmination of students' learning in the course, assessing their comprehensive understanding and proficiency in various topics in the course. It provides a structured platform for students to demonstrate their knowledge, problem-solving abilities, and application of theoretical concepts, ultimately gauging their readiness to progress. Pattern of End term question paper

Section	Total Questions	Marks for each question	have to attempt	Total Marks
A	5	4	4	20
B	5	10	3	30
C	4	15	2	30

PRACTICUM:

(A) Internal assessment: (20 marks): In the internal assessment of the practicum components, the student's performance, understanding, skills, sincerity, and involvement in laboratory work during the entire semester are evaluated.

(B) End-term examination (80 marks): The ability to apply theoretical knowledge to real-world situations is the fundamental criterion used in the End Term examination. It typically involves students' activity on randomly assigned laboratory works and the Laboratory Report (Notebook) on the performed work in the entire semester. In the End examination, the student must complete randomly assigned tasks and prepare a report on their work, including appropriate conclusions. The mark distribution for the End term examination as follows.

Activity	Marks
Laboratory work in the Examination	40
Laboratory Notebook	20
Presentation/Viva-voce	20

PHY-001-CC-4130: PHYSICS OF SOLID-STATE DEVICES

NCrF Level:	6.0		
Programme:	Four Year Undergraduate Programme	**Semester:**	Seventh
Course Category:	Major Course (Core Course)		
Credit (L: T: P)	3: 0: 2		
Credit Hours	Theory: 45 Hours, Practicum: 60 Hours		

1.0 COURSE LEARNING OBJECTIVES

This course provides an in-depth understanding of the physics, operation, and characteristics of solid-state devices. The Learning Objectives of the course are:

- To understand the fundamental physical principles of solid-state materials.
- To analyze and design basic semiconductor devices.
- To explore the applications of solid-state devices in modern electronics.

2.0 COURSE LEARNING OUTCOME

After completing this course, students will be able to,

CO	Outcomes
CO1:	Learn the concepts of carrier generation, recombination, and transport mechanisms in semiconductors, and to understand the working principles of semiconductor electronic devices.
CO2:	Understand the mechanism behind the formation of the depletion layer and its effect on carrier transport in the PN junction diode, and its characteristics diodes.
CO3:	Learn to explain the transport mechanism of BJTs and to analyze their characteristics and stability with the variation of concertation of the charge carrier and temperature.
CO4:	Learn the carrier transport and operation of Field effect transistor (JFET and MOSFET) and their fabrication for various technological applications.
CO5:	Learn the function and importance of MOSFET in CMOS technology along with the use of MOSFET in the fabrication logic gates and digital integrated circuits.
CO6:	Learn the processes involved in semiconductor device fabrication, including material preparation, lithography, doping and etching used in creating integrated circuits.
CO7:	Understand the working mechanism and apply power semiconductor devices including diodes, BJTs, MOSFETs, IGBTs, SCRs, TRIACs, and DIACs in power electronic circuits.
CO8:	Learn the basics of dielectric materials and its role in the fabrication of solid-state electronic devices like MOSFET, High frequency devices and in display technologies.
CO9:	Enhance the proficiency in conducting experiments with solid-state devices and learn the transport of charge carrier in this device in the laboratory.
CO10:	Able to prepare clear, structured, and concise scientific reports, effectively presenting laboratory works and findings with enhanced clarity.

3.0 SKILLS TO BE LEARNED

- To describe the working mechanism of various electronic components
- To select various electronic component as per the requirements
- Practical Use of various electronic components

4.0 DETAILED CONTENTS OF THE COURSE: THEORY

Credit: 3 **Classroom Teaching: 45 Horus**

MODULE 1

Semiconductor Materials: Carrier transport in semiconductors, drift, conductivity and mobility, a variation of mobility with temperature and doping, Intrinsic and extrinsic semiconductors – energy bands, Hall Effect. Diffusion, Einstein relations, Poisson equations, Continuity equations, Current flow equations, Diffusion length, Gradient of the quasi-Fermi level **[3 hours]**

Semiconductor Diodes: Formation of PN junctions, Built-in potential, Junction capacitance and transient behaviour, Ideal diode equation and Shockley diode model, forward and revise characteristics, , breakdown mechanisms and its temperature dependency, Diode Dynamic Behaviour - Transit time and junction capacitance modulation, switching and speed limitations, Zener diodes, Light-emitting diodes (LEDs), Photodiodes, PIN diode, Schottky diodes, Varactor diodes, Tunnel Diode, Gunn diode **[7 hours]**

Bipolar junction transistor (BJT) - current flow in BJT, Ebers-Moll model, configurations and characteristics, BJT Biasing – stability and temperature effect, Phototransistor**,** Darlington Transistor**,** Heterojunction Bipolar Transistor (HBT), Schottky-Barrier Transistor **[5 hours]**

MODULE 2

Field effect Transistor: Structure and operation of JFET - Transfer and output characteristics, JFET biasing methods; MOSFET structure, operation of enhancement and depletion types, $[I - V]$ characteristics, , Threshold voltage and channel modulation , MOSFET Biasing and Load Line Analysis - stable operation, MOSFET as a Switch, MoSFET in digital circuits – CMOS technology, logic gates with MOSFET, static and dynamic behaviour of MOSFET in digital circuits,. Insulated-Gate Bipolar Transistor (IGBT), High electron mobility transistor (HEMT) [**9 hours]**

Semiconductor Device Fabrication: Crystal Growth and Silicon Wafer Preparation - Czochralski and Float-Zone methods, Photolithography – photoresists, mask design, exposure systems, role of oxidation in device fabrication, oxide growth kinetics, Doping techniques - Diffusion doping, Ion implantation, Annealing and activation of dopants, Junction formation and depth control, Etching techniques – Anisotropic and isotropic etching, etch stop layers and endpoint detection, Advanced Lithography Techniques - Extreme Ultraviolet (EUV) lithography, Electron beam lithography (EBL), Nanoimprint lithography (NIL) Metallization and Interconnects -Metal deposition techniques, Packaging and Testing . **[6 hours]**

MODULE 3

Power Semiconductor Devices: Power diodes, Power BJTs, Power MOSFETs, Insulated Gate Bipolar Transistors (IGBTs), Thyristors: SCRs, TRIACs, and DIACs **[4 hours]**

Dielectric materials in electronic devices: Types of dielectric materials: organic, inorganic, composite, polarization mechanisms**,** Dielectric constant (permittivity), Dielectric loss and loss tangent, Complex permittivity, Measurement methods: capacitance, impedance, and bridge methods, Role of gate dielectrics in MOSFETs ,Requirements for gate dielectrics: high-k materials, Common gate dielectric materials (e.g., SiO_2, HfO_2), Impact on device scaling and performance, Dielectrics in Integrated Circuits and memory devices, dielectric materials in display technologies - dielectrics in capacitive touchscreens, dielectrics in RF and Microwave Devices - resonators and filters, substrates in RF circuits, Dielectric Materials in Sensors and Actuators - Piezoelectric and pyroelectric materials. **[12 hours]**

5.0 DETAILED CONTENTS OF THE COURSE: PRACTICUM

Credit: 2 **Laboratory Work: 60 Hours**

In the practicum component of the course, students will learn the physics behind the solid-state electronic devices though a series of laboratory experiment. They have to go through hands-on experience with different types of solid-state devices and measuring instruments to determine their characteristics and parameters. Students are required to conduct experiments from the provided list, meticulously following the suggested procedures and protocols outlined for each. Subsequently, they must compile comprehensive reports for every experiment, adhering to scientific standards and conventions. These reports should encompass a detailed description of the experimental setup and methodology employed, including any modifications made during the course of the experiment. Furthermore, students are expected to record and analyze their experimental data systematically, drawing upon relevant theoretical concepts and principles to interpret their findings accurately. Additionally, the reports should include a thorough discussion of the results obtained, highlighting any observed trends, anomalies, or correlations, and offering insightful explanations or hypotheses where applicable. Moreover, students must demonstrate proficiency in presenting their results graphically, utilizing tables, figures, and diagrams to enhance clarity and facilitate comprehension. Finally, each report should conclude with a succinct summary of the key findings and conclusions drawn from the experiment, along with any recommendations for further investigation or improvement.

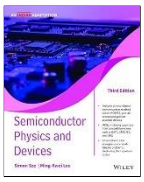
The teacher has the flexibility to introduce a wide range of laboratory experiments that directly correlate with and reinforce the theoretical concepts covered in the course curriculum. These experiments serve as practical applications of the theoretical principles discussed in lectures.

Suggested List of Experiments:

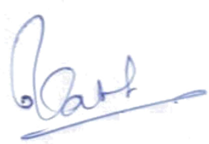
1. Study the temperature dependence of resistivity of a semiconductor (Four probe method) and to determine band gap of experimental material.
2. To study Hall effect and determine the Hall Coefficient, Carrier Density and Carrier mobility of a semiconductor sample
3. Draw the [V-I] characteristic & calculate cut-in voltage, reverse Saturation current and static & dynamic resistances of –(a) A silicon diode (b) A Germanium diode (c) A Schottky diode (d) A switching diode
4. Draw the [V-I] characteristic of a Silicon diode & calculate cut-in voltage, reverse Saturation current and static & dynamic resistances at five different temperatures.
5. Draw the [V-I] characteristic of two different Zener diode & calculate cut-in voltage, reverse Saturation current, break down voltage.
6. Draw the [V-I] characteristic of two different Zener diode at five different temperature and analysis their characteristics.
7. To study Zener diode as voltage regulator for (a) fixed input voltage and variable load (b) fixed load and variable input voltage and determine load regulation and line regulation.
8. Draw the characteristics of a LDR and a photodiode for five different light illumination conditions and analysis their characteristics.
9. Study the variation of Junction capacitance of a PN Junction diode and Schottky Diode at five different temperatures
10. To study the basic effect of temperature on electrical and optical characteristics of Light Emitting Diodes of different types
11. To study the LED Efficiency and Luminous Efficacy at different temperature.

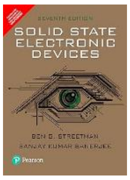
12. To study the characteristics of a varistor and evaluate its effectiveness in protecting electronic circuits from transient overvoltage events.
13. To draw the static input and output characteristics curves of a transistor in CE configuration at different temperature and compare the variation of h parameter.
14. To draw the static input and output characteristics curves of a transistor in CB configuration at different temperature and compare the variation of h parameter.
15. To draw the static input and output characteristics curves of a transistor in CC configuration at different temperature and compare the variation of h parameter.
16. To draw the $[V - I]$ characteristics of a photo transistor under different light illumination.
17. To measure and analyze the I-V characteristics of a Unijunction Transistor and determine its key parameters, including the peak voltage, peak current, valley voltage, and intrinsic standoff ratio (η).
18. To study the variation of UJT parameters like peak voltage, peak current, valley voltage, and intrinsic standoff ratio (η) with temperature.
19. To characterize the electrical properties of a Field-Effect Transistor (FET) and understand its behavior under different biasing conditions.
20. To characterize the electrical properties of a Metal-Oxide-Semiconductor Field-Effect Transistor (MOSFET) and understand its behavior under different biasing conditions.
21. To characterize the electrical properties of a Silicon-Controlled Rectifier (SCR) and understand its behavior in various circuit configurations.
22. To characterize the electrical properties of a Triode for Alternating Current (TRIAC) and understand its behavior in various circuit configurations.
23. To characterize the electrical properties of a Diode Alternating Current Switch (DIAC) and understand its behavior in various circuit configurations.
24. To study the change of dielectric properties with temperature by heating or cooling the sample while measuring its dielectric constant and loss.
25. To study the variation of dielectric constant with temperature and determination the Curie temperature of a given ferroelectric ceramics.
26. To study the dielectric breakdown and determine the maximum electric field the material can withstand before breakdown occurs.
27. To study the dielectric Loss and measure the energy dissipated as heat when the material is subjected to an alternating electric field.
28. To study the variation of the dielectric properties with frequency using techniques like impedance analysis or network analysis.
29. To study the dielectric relaxation process in the material by analyzing its response to an external electric field as a function of time.
30. To study the dielectric properties over a range of frequencies suing impedance spectroscopy or dielectric spectroscopy.
31. To study the polarization behavior of a dietetic material under different electric field strengths and frequencies.
32. To the ability of the dialectic material to store electric charge.

6.0 TEXT BOOKS



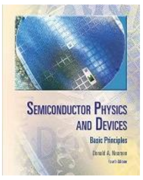
Name: Semiconductor Physics and Devices
Author: S. M. Sze and M. K. Lee
Edition: 3rd Ed.
Publisher: Wiley
ISBN: 978-9354243226



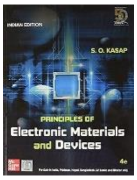


Name: Solid State Electronic Devices
Author: Ben G. Streetman
Edition: 7th Ed.
Publisher: Pearson Education
ISBN: 978-9332555082

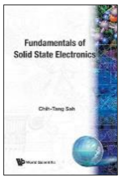
7.0 REFERENCE BOOKS AND MATERIALS



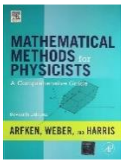
Name: Semiconductor Physics and Devices: Basic Principles
Author: Donald A. Neamen
Edition: McGraw-Hill Education
Publisher: 4th Ed.
ISBN: 978-0073529585



Name: Principles of Electronic Materials and Devices
Author: Safa O. Kasap
Edition: McGraw-Hill Education
Publisher: 4th Ed
ISBN: 978-9390113866



Name: Fundamentals of Solid-State Electronics
Author: Chih-Tang Sah and T. C. McGill
Edition: 1991
Publisher: World Scientific Publishing Co Pte Ltd
ISBN: 978-9810206383



Name: Semiconductor Devices: Basic Principles
Author: Jasprit Singh
Edition: 2007
Publisher: Wiley
ISBN: 978-8126511020

8.0 MAPPING OF CLO TO PO AND PSO

The course outcomes and their mapping with program outcomes are specified in the table below

Course Learning Outcomes	Programme Outcomes (POs)												Programme Specific Outcome (PSOs)					
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6
CO1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

9.0 ASSESSMENT SCHEME

The evaluation system for this course consists of an 80% weightage on a comprehensive theory examination, which assesses students' understanding of various course topics, and a 20% weightage allocated to internal assessments, including internal examinations, assignments, class participation, and overall engagement in the course throughout the semester.

THEORY:

(A) Internal assessment: (20 marks): Continuous evaluation and internal assessment are implemented to foster and maintain a thorough understanding throughout the learning process. By regularly assessing comprehension through assignments, quizzes, and class participation, educators can address learning gaps promptly and support students in achieving deeper knowledge and proficiency in the subject matter.

(B) End-term examination (80 marks): The end-term examination serves as a culmination of students' learning in the course, assessing their comprehensive understanding and proficiency in various topics in the course. It provides a structured platform for students to demonstrate their knowledge, problem-solving abilities, and application of theoretical concepts, ultimately gauging their readiness to progress. Pattern of End term question paper

Section	Total Questions	Marks for each question	have to attempt	Total Marks
A	5	4	4	20
B	5	10	3	30
C	4	15	2	30

PRACTICUM:

(A) Internal assessment: (20 marks): In the internal assessment of the practicum components, the student's performance, understanding, skills, sincerity, and involvement in laboratory work during the entire semester are evaluated.

(B) End-term examination (80 marks): The ability to apply theoretical knowledge to real-world situations is the fundamental criterion used in the End Term examination. It typically involves students' activity on randomly assigned laboratory works and the Laboratory Report (Notebook) on the performed work in the entire semester. In the End examination, the student must complete randomly assigned tasks and prepare a report on their work, including appropriate conclusions. The mark distribution for the End term examination as follows.

Activity	Marks
Laboratory work in the Examination	40
Laboratory Notebook	20
Presentation/Viva-voce	20

PHY-001-CC-4140: NUMERICAL METHODS IN PHYSICS

NCrF Level: 6.0

Programme: Four Year Undergraduate Programme **Semester:** Seventh

Course Category: Major Course

Credit (L: T: P) 3: 0: 2

Credit Hours Theory: 45 Hours, Practicum: 60 Hours

1.0 COURSE LEARNING OBJECTIVES

This course introduces numerical methods commonly used in solving physics problems where analytical solutions are impractical or impossible. The Learning outcomes of the course are:

- Understand the limitations of numerical methods and when they are appropriate.
- Solve linear and nonlinear equations using iterative methods
- Apply interpolation techniques and perform curve fitting.
- Implement algorithms for numerical differentiation and integration.
- Solve ordinary and partial differential equations using numerical techniques.
- Analyze and interpret numerical results in the context of physical problems.

2.0 COURSE LEARNING OUTCOME

After completing this course, students will be able to,

CO	Outcomes
CO1:	Get a solid foundation in numerical analysis, focusing on understanding and managing errors in computations, analyzing convergence properties.
CO2:	Understand how to define and classify different types of errors in numerical computations and Identify sources of numerical errors in algorithms and computational procedures.
CO3:	Learn to apply numerical methods to find roots of algebraic and transcendental equations, analyze error and convergence properties, and interpret solutions in various scientific contexts.
CO4:	Learn the principle, Gaussian elimination, decomposition and iterative methods to solve linear systems of equations.
CO5:	Equip students with both theoretical understanding and practical skills in interpolation and curve fitting, emphasizing their application in solving physics problems
CO6:	Learn to implement, analyze, and apply numerical differentiation and integration techniques to solve practical problems.
CO7:	Learn to formulate, solve, and analyze ordinary and partial differential equations using various numerical methods, and to apply these techniques solve complex real-world problems.
CO8:	Develop, write, and debug programs using fundamental programming constructs to solve a variety of computational problems.
CO9:	To effectively utilize and integrate Python libraries and modules to extend program functionality, manage dependencies, and enhance the modularity and efficiency of their code
CO10:	implement and apply numerical methods using Python to solve complex mathematical problems and analyze their solutions.

3.0 SKILLS TO BE LEARNED

- to develop, analyze, and apply numerical algorithms for solving problems in physics.
- To develop, write, and debug python programs as per the requirements.
- To use of and integrate Python libraries and modules.

4.0 DETAILED CONTENTS OF THE COURSE: THEORY

Credit: 3 **Classroom Teaching: 45 Horus**

MODULE 1

Introduction to Numerical analysis: Errors in Numerical computations, Error analysis and estimates, significant digits, convergence. General error formula, Linear convergence and quadratic convergence Examples **[2 hours]**

Root Finding Methods of nonlinear equations: Iteration method**,** Bisection Method, Regula- Falsi method, Practical examples, Newton Raphson Method, Secant method, Ramanujan's Method, Newton Raphson method for Nonlinear system of equations. Applications in Physics problems. **[5 hours]**

Solution of linear systems: Matrix Inverse method, Gauss elimination method, Gauss-Jordan elimination - matrix inversion, Iterative methods - Gauss-Jacobi and Gauss- Seidel method, Eigenvalues and Eigenvectors - power methods, Jacobi's Method for Symmetric matrix, Method of Factorization - Doolittle Method, Crout Method, Cholesky Decomposition [**8 hours]**

MODULE 2

Interpolation: Finite difference operators - forward difference operator, backward difference operator, central difference operator, Shift operator, Displacement operator, relation between these operators, Newton forward and backward interpolation formula, Gauss' forward and backward interpolation formula, Stirling's formula, Bessels' formula. Lagrange's interpolation, Newton's divided difference formula, Error estimation in interpolation formula. Linear interpolation, Lagrange interpolation method, Newton Interpolation formula, Practical examples **[7 hours]**

Numerical differentiation: Derivative using interpolation formula, Higher order derivatives, determination of maxima and minima [**[2 hours]**

Numerical Integration: General Quadrature formula, Trapezoidal rule, Simpson's 1/3 rd rule, Simpson's 3/8 th rule, Geometrical explanation, error in numerical integration, Two and Three point Gaussian Quadrature Formulae, Double integration - Trapezoidal rule and Simpson's rule **[6 hours]**

MODULE 3

Ordinary Differential Equation: Taylor's series method, Euler's method and modified Euler's method - geometrical explanation, Runge - Kutta method, Picard's Method, finite difference methods for solution of second order ordinary differential equation, **[7 hours]**

Partial Differential Equation: Finite difference method, Hyperbolic, Parabolic, and Elliptic Equations by finite difference. Heat equation, wave equation and Laplace equation, applications in heat conduction, wave propagation and electronics, Application to 2-dimensional Electrostatic Field problems. Solution of eigen value problems, solution of Schrodinger equations. **[8 hours]**

5.0 DETAILED CONTENTS OF THE COURSE: PRACTICUM

Credit: 2 **Laboratory Work: 60 Hours**

In the practicum component of the course students learn basics of python and its libraries like NumPy, SciPy, Matplotlib during the laboratory classes. They have to go through exercise related to the use of the function of these libraries. They have to apply these programming skills and library functions in mathematical computation, numerical calculations in the laboratory classes.

(a) **Review on Python:** Concepts of programming and algorithm, flowchart, python IDE - Anaconda, Spyder, Jupyter notebooks, Python syntax, data types, and operators, Python scripts, conditional statements (if-else) and loops (for, while) lists, tuples, dictionaries, and sets, reading from and writing to files in Python, Python Libraries and Modules NumPy, SciPy, Matplotlib, Pandas etc

(b) **NumPy Fundamentals:** Overview of NumPy and its importance, Installing and importing NumPy, NumPy documentation and resources, Difference between List and NumPy array, Creating NumPy arrays from lists and other data structures, Array attributes and data types, Basic Array Operations – indexing, slicing, iterating over arrays, Basic arithmetic operations on arrays, reshaping and resizing arrays, creating arrays using ones(), zeros(), random(), arange(), linspace(), multidimensional arrays – matrix operation and multidimensional arrays. Input and output with NumPy – Reading and writing to files, handling different file formats (CSC, binary etc.)

(c) Matplotlib: Overview of Matplotlib and its importance, Installing and importing Matplotlib, Basic Plotting - Line plots, scatter plots, and bar charts, Figure and Axes objects - creating subplots and multiple axes, Histograms, pie charts, and box plots, working with colours, markers, and line styles, Using stylesheets and themes, Integrating Matplotlib with Pandas Data frames, plotting directly from pandas objects. Creating interactive plots using widgets, Integrating Matplotlib with interactive environments like Jupyter Notebook, 3D Plotting **–** surface plots and 3D visualizations, saving plots to different file formats, Customizing export settings for publication-quality figures

(d) **SciPy Fundamentals:** Overview of SciPy and its importance, Installing and importing SciPy, Linear Algebra with SciPy - Solving linear systems of equations, Eigenvalues and eigenvectors, matrix decomposition, optimization and root finding, Numerical integration using SciPy, solving ordinary differential equation, interpolation and curve fitting using SciPy, input and output with SciPy.

(e) **Generation of Special functions**: Generating and plotting Legendre Polynomials Generating and plotting Bessel function.

Suggestive exercise of NumPy Library

(a) NumPy Basic

1. Write a NumPy program to get the NumPy version and show the NumPy build configuration.
2. Write a NumPy program to get help with the add function.
3. Write a NumPy program to test whether none of the elements of a given array are zero.
4. Write a NumPy program to test if any of the elements of a given array are non-zero.
5. Write a NumPy program to test a given array element-wise for finiteness (not infinity or not a number).
6. Write a NumPy program to test elements-wise for positive or negative infinity.
7. Write a NumPy program to test element-wise for 'NaN' of a given array.
8. Write a NumPy program to test element-wise for complex numbers, real numbers in a given array. Also test if a given number is of a scalar type or not.
9. Write a NumPy program to test whether two arrays are element-wise equal within a tolerance.
10. Write a NumPy program to create an element-wise comparison (greater, greater equal, less and less equal) of two given arrays.
11. Write a NumPy program to create an element-wise comparison (equal, equal within a tolerance) of two given arrays.
12. Write a NumPy program to create an array with the values 1, 7, 13, 105 and determine the size of the memory occupied by the array.
13. Write a NumPy program to create an array of 10 zeros, 10 ones, and 10 fives.
14. Write a NumPy program to create an array of integers from 30 to 70.
15. Write a NumPy program to create an array of all even integers from 30 to 70.
16. Write a NumPy program to create a 3x3 identity matrix.
17. Write a NumPy program to generate a random number between 0 and 1.

18. Write a NumPy program to generate an array of 15 random numbers from a standard normal distribution.
19. Write a NumPy program to create a vector with values ranging from 15 to 55 and print all values except the first and last.
20. Write a NumPy program to create a 3X4 array and iterate over it.
21. Write a NumPy program to create a vector of length 10 with values evenly distributed between 5 and 50.
22. Write a NumPy program to create a vector with values from 0 to 20 and change the sign of the numbers in the range from 9 to 15.
23. Write a NumPy program to create a vector of length 5 filled with arbitrary integers from 0 to 10.
24. Write a NumPy program to multiply the values of two given vectors.
25. Write a NumPy program to create a 3x4 matrix filled with values from 10 to 21.
26. Write a NumPy program to find the number of rows and columns in a given matrix.
27. Write a NumPy program to create a 3x3 identity matrix, i.e. the diagonal elements are 1, the rest are 0.
28. Write a NumPy program to create a 10x10 matrix, in which the elements on the borders will be equal to 1, and inside 0.
29. Write a NumPy program to create a 5x5 zero matrix with elements on the main diagonal equal to 1, 2, 3, 4, 5.
30. Write a NumPy program to create a 4x4 matrix in which 0 and 1 are staggered, with zeros on the main diagonal.
31. Write a NumPy program to create a 3x3x3 array filled with arbitrary values.
32. Write a NumPy program to compute the sum of all elements, the sum of each column and the sum of each row in a given array.
33. Write a NumPy program to compute the inner product of two given vectors.
34. Write a NumPy program to add a vector to each row of a given matrix.
35. Write a NumPy program to save a given array to a binary file.
36. Write a NumPy program to save a given array to a binary file.
37. Write a NumPy program to save a given array to a text file and load it.
38. Write a NumPy program to convert a given array into bytes, and load it as an array.
39. Write a NumPy program to convert a given list into an array, then again convert it into a list. Check if initial list and final list are equal or not.
40. Write a NumPy program to compute the x and y coordinates for points on a sine curve and plot the points using matplotlib.
41. Write a NumPy program to convert numpy dtypes to native Python types
42. Write a NumPy program to add elements to a matrix. If an element in the matrix is 0, we will not add the element below this element.
43. Write a NumPy program to find missing data in a given array.
44. Write a NumPy program to check whether two arrays are equal (element wise) or not.
45. Write a NumPy program to create a one-dimensional array of single, two and three-digit numbers.
46. Write a NumPy program to create a two-dimensional array of a specified format.
47. Write a NumPy program to create a one-dimensional array of forty pseudo-randomly generated values. Select random numbers from a uniform distribution between 0 and 1.
48. Write a NumPy program to create a two-dimensional array with shape (8,5) of random numbers. Select random numbers from a normal distribution (200,7).
49. Write a NumPy program to generate a uniform, non-uniform random sample from a given 1-D array with and without replacement.
50. Write a NumPy program to create a 4x4 array with random values. Create an array from the said array swapping first and last rows.
51. Write a NumPy program to create a new array of given shape (5,6) and type, filled with zeros.
52. Write a NumPy program to sort a given array by row and column in ascending order.
53. Write a NumPy program to extract all numbers from a given array less and greater than a specified number.

54. Write a NumPy program to replace all numbers in a given array equal, less and greater than a given number.
55. Write a NumPy program to create an array of equal shape and data type for a given array.
56. Write a NumPy program to create a three-dimensional array with the shape (3,5,4) and set it to a variable.
57. Write a NumPy program to create a 4x4 array. Create an array from said array by swapping first and last, second and third columns.
58. Write a NumPy program to swap rows and columns of a given array in reverse order.
59. Write a NumPy program to multiply two given arrays of the same size element-by-element.

(b) NumPy Linear Algebra

1. Write a NumPy program to compute the multiplication of two given matrices.
2. Write a NumPy program to compute the outer product of two given vectors.
3. Write a NumPy program to compute the cross product of two given vectors.
4. Write a NumPy program to compute the determinant of a given square array.
5. Write a NumPy program to evaluate Einstein's summation convention of two given multidimensional arrays.
6. Write a NumPy program to compute the inner product of vectors for 1-D arrays (without complex conjugation) and in higher dimension.
7. Write a NumPy program to compute the eigenvalues and right eigenvectors of a given square array.
8. Write a NumPy program to compute the Kronecker product of two given multidimension arrays.
9. Write a NumPy program to compute the condition number of a given matrix.
10. Write a NumPy program to find a matrix or vector norm.
11. Write a NumPy program to compute the determinant of an array.
12. Write a NumPy program to compute the inverse of a given matrix.
13. Write a NumPy program to calculate the QR decomposition of a given matrix.
14. Write a NumPy program to compute the condition number of a given matrix.
15. Write a NumPy program to compute the sum of the diagonal element of a given array.
16. Write a NumPy program to get the lower-triangular L in the Cholesky decomposition of a given array.
17. Write a NumPy program to get the qr factorization of a given array.
18. Write a NumPy program to compute the factor of a given array by Singular Value Decomposition.
19. Write a NumPy program to calculate the Frobenius norm and the condition number of a given array.

(c) NumPy Random:

1. Write a NumPy program to generate five random numbers from the normal distribution.
2. Write a NumPy program to generate six random integers between 10 and 30.
3. Write a NumPy program to create a 3x3x3 array with random values.
4. Write a NumPy program to create a 5x5 array with random values and find the minimum and maximum values.
5. Write a NumPy program to create a random 10x4 array and extract the first five rows of the array and store them into a variable.
6. Write a NumPy program to shuffle numbers between 0 and 10 (inclusive).
7. Write a NumPy program to normalize a 3x3 random matrix.
8. Write a NumPy program to create a random vector of size 10 and sort it.
9. Write a NumPy program to find the nearest value from a given value in an array.
10. Write a NumPy program to check if two random arrays are equal or not.
11. Write a NumPy program to create a random vector of size 15 and replace the maximum value by -1.
12. Write a NumPy program to find point by point distances of a random vector with shape (10,2) representing coordinates.
13. Write a NumPy program to find the most frequent value in an array.
14. Write a NumPy program to convert cartesian coordinates to polar coordinates of a random 10x2 matrix representing cartesian coordinates.
15. Write a NumPy program to find the closest value (to a given scalar) in an array.

16. Write a NumPy program to get the n largest values of an array.
17. Write a NumPy program to create a three-dimensional array with shape (300,400,5) and set to a variable. Fill the array elements with values using unsigned integers (0 to 255).

(d) Sorting and Searching:

1. Write a NumPy program to sort a given array of shape 2 along the first axis, last axis and flattened array.
2. Write a NumPy program to create a structured array from given student name, height, class and their data types. Now sort the array on height.
3. Write a NumPy program to create a structured array from given student name, height, class and their data types. Now sort by class, then height if class is equal.
4. Write a NumPy program to sort the student id with increasing height of the students from given students id and height. Print the integer indices that describe the sort order by multiple columns and the sorted data.
5. Write a NumPy program to get the indices of the sorted elements of a given array.
6. Write a NumPy program to sort a given complex array using the real part first, then the imaginary part.
7. Write a NumPy program to partition a given array in a specified position and move all the smaller elements values to the left of the partition, and the remaining values to the right, in arbitrary order (based on random choice).
8. Write a NumPy program to sort the specified number of elements from the beginning of a given array.
9. Write a NumPy program to sort a given array by the nth column.

(e) NumPy Mathematics:

1. Write a NumPy program to add, subtract, multiply, divide arguments element-wise.
2. Write a NumPy program to compute logarithm of the sum of exponentiations of the inputs, sum of exponentiations of the inputs in base-2.
3. Write a NumPy program to get true division of the element-wise array inputs.
4. Write a NumPy program to get the largest integer smaller or equal to the division of the inputs.
5. Write a NumPy program to get the powers of an array values element-wise.
6. Write a NumPy program to get the element-wise remainder of an array of division.
7. Write a NumPy program to calculate the absolute value element-wise.
8. Write a NumPy program to round array elements to the given number of decimals.
9. Write a NumPy program to round elements of the array to the nearest integer.
10. Write a NumPy program to get the floor, ceiling and truncated values of the elements of a numpy array.
11. Write a NumPy program to multiply a 5x3 matrix by a 3x2 matrix and create a real matrix product.
12. Write a NumPy program to multiply a matrix by another matrix of complex numbers and create a new matrix of complex numbers.
13. Write a NumPy program to create an inner product of two arrays
14. Write a NumPy program to generate inner, outer, and cross products of matrices and vectors.
15. Write a NumPy program to generate a matrix product of two arrays.
16. Write a NumPy program to find the roots of the following polynomials.
    (i) $x^2 - 4x = 7$
    (ii) $x^4 - 11x^3 + 9x^2 + 11x = 10$
17. Write a NumPy program to compute the following polynomial values for $x = 2$ and $x = 3$
    (i) $x^2 - 4x - 7$
    (ii) $x^4 - 11x^3 + 9x^2 + 11x - 10$
18. Write a NumPy program to add one polynomial to another, subtract one polynomial from another, multiply one polynomial by another and divide one polynomial by another.
19. Write a NumPy program to calculate mean across dimension, in a 2D NumPy array.
20. Write a NumPy program to create a random array with 1000 elements and compute the average, variance, standard deviation of the array elements.
21. Write a NumPy program to compute the trigonometric sine, cosine and tangent array of angles given in degrees.
22. Write a NumPy program to calculate inverse sine, inverse cosine, and inverse tangent for all elements in a given array

23. Write a NumPy program to convert angles from radians to degrees for all elements in a given array.
24. Write a NumPy program to convert angles from degrees to radians for all elements in a given array.
25. Write a NumPy program to calculate hyperbolic sine, hyperbolic cosine, and hyperbolic tangent for all elements in a given array.
26. Write a NumPy program to calculate round, floor, ceiling, truncated and round (to the given number of decimals) of the input, element-wise of a given array.
27. Write a NumPy program to calculate the cumulative sum of the elements along a given axis, sum over rows for each of the 3 columns and sum over columns for each of the 2 rows of a given 3x3 array.
28. Write a NumPy program to calculate cumulative product of the elements along a given axis, sum over rows for each of the 3 columns and product over columns for each of the 2 rows of a given 3x3 array.
29. Write a NumPy program to calculate the difference between neighboring elements, element-wise of a given array.
30. Write a NumPy program to calculate the difference between neighboring elements, element-wise, and prepend [0, 0] and append[200] to a given array
31. Write a NumPy program to compute e^x, element-wise given array.
32. Write a NumPy program to calculate $e^x - 1$ for all elements in a given array.
33. Write a NumPy program to calculate 2p for all elements in a given array.
34. Write a NumPy program to compute natural, base 10, and base 2 logarithms for all elements in a given array.
35. Write a NumPy program to compute the natural logarithm of one plus each element of a given array in floating-point accuracy.
36. Write a NumPy program to check element-wise True/False of a given array where the sign bit is set.
37. Write a NumPy program to change the sign of a given array to that of a given array, element-wise
38. Write a NumPy program to compute numerical negative values for all elements in a given array.
39. Write a NumPy program to compute the reciprocal for all elements in a given array.
40. Write a NumPy program to compute xy, element-wise where x, y are two given arrays.
41. Write a NumPy program to compute an element-wise indication of the sign for all elements in a given array.

(f) NumPy String

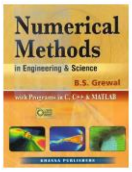
1. Write a NumPy program to concatenate element-wise two arrays of string.
2. Write a NumPy program to repeat all the elements three times of a given array of string
3. Write a NumPy program to capitalize the first letter, lowercase, uppercase, swapcase, title-case of all the elements of a given array.
4. Write a NumPy program to make the length of each element 15 of a given array and the string centered / left-justified / right-justified with paddings of _Original Array: ['python exercises', 'PHP', 'java', 'C++']
5. Write a NumPy program to encode all the elements of a given array in cp500 and decode it again.
6. Write a NumPy program to remove the leading and trailing whitespaces of all the elements of a given array.
7. Write a NumPy program to remove the leading whitespaces of all the elements of a given array.

Suggestive list for exercise: Matplotlib

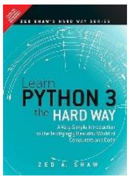
1. Write a Python program to draw a line with a suitable label in the x axis, y axis and a title.
2. Write a Python program to draw a line using given axis values with suitable labels in the x axis , y axis and a title.
3. Write a Python program to draw a line using given axis values taken from a text file, with suitable labels in the x axis, y axis and a title.
4. Write a Python program to draw line charts of the experimental data .
5. Write a Python program to plot two or more lines on the same plot with suitable legends of each line.
6. Write a Python program to plot two or more lines with legends, different widths and colors.
7. Write a Python program to plot two or more lines with different styles.
8. Write a Python program to plot two or more lines and set the line markers.

9. Write a Python program to display the current axis limits values and set new axis values.
10. Write a Python program to plot quantities which have an x and y position.
11. Write a Python program to plot several lines with different format styles in one command using arrays.
12. Write a Python program to create multiple types of charts (a simple curve and plot some quantities) on a single set of axes.
13. Write a Python program to display the grid and draw line charts of the data of an experiment and customize the grid lines with line-style -, width 0.5 and color blue.
14. Write a Python program to display the grid and draw line charts of data of an experiment. Customized the grid lines with rendering with a larger grid (major grid) and a smaller grid (minor grid). Turn on the grid but turn off ticks.
15. Write a Python program to create multiple plots of different data sets in a single chart.
16. Write a Python program to display a bar chart of the temperature of your location in the last 7 days.
17. Write a Python program to display a horizontal bar chart of the temperature of your location in the last 7 days.
18. Write a Python programming to display a bar chart of Languages the temperature of your location in the last 7 days. Use a different color for each bar.
19. Write a Python programming to display a bar chart of Languages the temperature of your location in the last 7 days. Attach a text label above each bar and mention the curve.
20. Write a Python programming to display a bar chart of Languages the temperature of your location in the last 7 days. Make a blue border to each bar.
21. Write a Python programming to display a bar chart of Languages the temperature of your location in the last 7 days. Specify the position of each bar plot.
22. Write a Python programming to display a bar chart of Languages the temperature of your location in the last 7 days. Select the width of each bar and their positions.
23. Write a Python programming to display a bar chart of Languages the temperature of your location in the last 7 days. Increase bottom margin.
24. Write a Python program to display a bar chart of Languages the temperature of two locations in the last 7 days in the same chart.
25. Write a Python program to create bar plot from a Data Frame (temperature of five locations in the same chart)
26. Write a Python program to create bar plots with error bars for a data set of an experiment. Attach text level in each bar.
27. Write a Python program to create a stacked bar plot with error bars.
28. Write a Python program to create a horizontal bar chart with differently ordered colors.
29. Write a Python program to create stacked bar plots and add labels to each section.
30. Write a Python program to add textures (black and white) to bars and wedges.
31. Write Python programming to create a pie chart of a data set.
32. Write Python programming to create a pie chart with detailed information about the chart.
33. Write Python programming to create a pie chart with detailed information about the chart. Make multiple wedges of the pie
34. Write a Python programming to create a pie chart by reading data from a csv file
35. Write a Python program to draw a scatter graph taking a random distribution in X and Y and plotting against each other.
36. Write a Python program to draw a scatter plot with empty circles taking a random distribution in X and Y and plotted against each other.
37. Write a Python program to draw a scatter plot using random distributions to generate balls of different sizes.
38. Write a Python program to draw a scatter plot comparing two subject marks.
39. Write a Python program to draw a scatter plot for three different groups comparing weights and heights.
40. Write a Python program to draw a scatter plot to find sea level rise in the past 100 years.

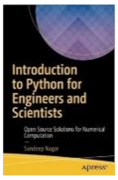
6.0 TEXT BOOKS



Name: Numerical Methods in Engineering & Science
Author: B. S. Grewal
Edition: 10^{th} Ed.
Publisher: Khanna Publishers
ISBN: 9788174092489

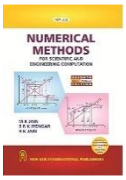


Name: Learn More Python 3 the Hard Way: The Next Step for New Python Programmers
Author: Zed Shaw
Edition:
Publisher:
ISBN: 978-9352865109

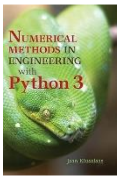


Name: Introduction to Python for Engineers and Scientists: Open-Source Solutions for Numerical Computation
Author: Sandeep Nagar
Edition: 1^{st} Ed. (2018)
Publisher: APRESS
ISBN: 978-1484247334

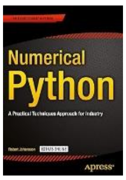
7.0 REFERENCE BOOKS AND MATERIALS



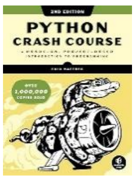
Name: Numerical Methods.
Author: M. K. Jain, S R K Iyengar, R. K. Jain
Edition: 7^{th} Ed.
Publisher: New Age International Private Limited
ISBN: 978-9387477254



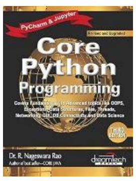
Name: Numerical Methods.
Author: Jaan Kiusalaas
Edition: 3^{rd}**. Ed.**
Publisher: Cambridge University Press
ISBN: 978-1107033856



Name: Numerical Python: A Practical Techniques Approach for Industry
Author: Robert Johansson
Edition: 1st
Publisher: Springer Nature
ISBN: 978-1484205549



Name: Python Crash Course
Author: Eric Matthes
Edition: 2^{nd} Ed (2019)
Publisher: No Starch Press
ISBN: 9781718502703



Name: Core Python Programming
Author: R. Nageswara Rao
Edition: 3^{rd}
Publisher: Wiley India Pvt Ltd.
ISBN: 978-9390457151

8.0 MAPPING OF CLO TO PO AND PSO

The course outcomes and their mapping with program outcomes are specified in the table below

Course Learning Outcomes	Programme Outcomes (POs)												Programme Specific Outcome (PSOs)					
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6
CO1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

9.0 ASSESSMENT SCHEME

The evaluation system for this course consists of an 80% weightage on a comprehensive theory examination, which assesses students' understanding of various course topics, and a 20% weightage allocated to internal assessments, including internal examinations, assignments, class participation, and overall engagement in the course throughout the semester.

THEORY:

(A) Internal assessment: (20 marks): Continuous evaluation and internal assessment are implemented to foster and maintain a thorough understanding throughout the learning process. By regularly assessing comprehension through assignments, quizzes, and class participation, educators can address learning gaps promptly and support students in achieving deeper knowledge and proficiency in the subject matter.

(B) End-term examination (80 marks): The end-term examination serves as a culmination of students' learning in the course, assessing their comprehensive understanding and proficiency in various topics in the course. It provides a structured platform for students to demonstrate their knowledge, problem-solving abilities, and application of theoretical concepts, ultimately gauging their readiness to progress. Pattern of End term question paper

Section	Total Questions	Marks for each question	have to attempt	Total Marks
A	5	4	4	20
B	5	10	3	30
C	4	15	2	30

PRACTICUM:

(A) Internal assessment: (20 marks): In the internal assessment of the practicum components, the student's performance, understanding, skills, sincerity, and involvement in laboratory work during the entire semester are evaluated.

(B) End-term examination (80 marks): The ability to apply theoretical knowledge to real-world situations is the fundamental criterion used in the End Term examination. It typically involves students' activity on randomly assigned laboratory works and the Laboratory Report (Notebook) on the performed work in the entire semester. In the End examination, the student must complete randomly assigned tasks and prepare a report on their work, including appropriate conclusions. The mark distribution for the End term examination as follows.

Activity	Marks
Laboratory work in the Examination	40
Laboratory Notebook	20
Presentation/Viva-voce	20

PHY-001-DE-4210: MOLECULAR PHYSICS AND SPECTROSCOPY

NCrF Level:	6.0	
Programme:	Four Year Undergraduate Programme	**Semester:** Eight
Course Category:	Major Course (Departmental Elective)	
Credit (L: T: P)	3: 0: 2	
Credit Hours	Theory: 45 Hours, Practicum: 60 Hours	

1.0 COURSE LEARNING OBJECTIVES

This course delves into the fundamental principles and advanced concepts of molecular physics. Students will explore the structure, dynamics, and interactions of molecules through spectroscopy. The Learning objectives of this course is

(a) To understand the principles of how light interacts with molecules
(b) To understand the theory behind rotational, vibrational, electronic and Raman spectra.
(c) To Interpret various molecular spectra to get detailed information about the molecule
(d) To learn the theory behind NMR, ESR, and Mossbauer spectroscopy, along with their applications.
(e) To understand the principles behind FTIR spectroscopy and its applications.
(f) To learn about different types of X-ray spectra, like XRD, XRF, XPS etc. and their applications.

2.0 COURSE LEARNING OUTCOME

After completing this course, students will be able to,

CO	Outcomes
CO1:	Learn the fundamental concepts such as molecular orbitals, valence bond theory, hybridization, and group theory applications in molecular physics.
CO2:	Get the knowledge to apply classical approaches to study dynamics of molecules and the use of Schrödinger equation to molecular systems to analyze molecular system.
CO3:	Understand the basic principles underlying the rotational motion of molecules and resulting quantized energy levels as well as their applications.
CO4:	Learn the principles of vibrational motion in molecules and to describe the vibrational energy levels in diatomic and polyatomic molecules.
CO5:	Learn to analyze and interpret electronic spectra to determine electronic transitions, molecular energy levels, and electronic structure of molecules.
CO6:	Get the comprehend the theoretical underpinnings of Raman spectra and skill identify Raman-active vibrational modes, and utilize spectral data to infer molecular structural details.
CO7:	understanding of the principles NMR and use of NMR spectra to determine molecular structure, chemical environments, and dynamic properties of molecules.
CO8:	Get the knowledge of basics of ESR spectra and its applications to determine electronic environments, magnetic properties, and structural aspects of molecules.
CO9:	Learn the basic theory behind the Mossbauer Spectroscopy, FTIR spectra and X-ray spectra and their use to study a molecule.
CO10:	

3.0 SKILLS TO BE LEARNED

- to apply quantum mechanics to describe molecular systems and predict molecular properties.
- to interpret spectroscopic data to determine molecular structure, identify functional groups, and analyze molecular dynamics.
- Apply spectroscopic techniques to investigate molecular interactions, chemical reactions, and environmental conditions.
- Develop skills to design and conduct experiments, analyze data, and interpret results in the context of molecular physics and spectroscopy research.

4.0 DETAILED CONTENTS OF THE COURSE: THEORY

Credit: 3 **Classroom Teaching: 45 Horus**

MODULE 1

Introduction to Molecular Physics: Review of atomic physics and molecular structure, molecular bonding (covalent, ionic, hydrogen, van-der wal), Bonding and antibonding orbitals, Molecular orbital theory, Valence bond theory, Hybridization of orbitals,

Molecular Symmetry: Introduction to group theory, Symmetry operations and symmetry elements, Point groups and their applications in molecular physics , Symmetry and molecular vibrations,

Molecular Dynamics: Translational, rotational, and vibrational motion of molecules, Classical and quantum mechanical treatment of molecular dynamics , Collision theory and molecular interactions, Application of Schrödinger equation to molecular systems - Molecular orbitals and electron configurations, Hartree-Fock and Density Functional Theory

MODULE 2

Pure Rotation Spectra (Far Infrared spectroscopy): Rigid rotator, isotope effect, Determination of moment of inertia and bond length, non-rigid rotator, Rotation of molecules - symmetric Top and asymmetric top, stark effect in molecules. (5 Lectures)

Vibration of Molecules: Vibrating diatomic molecule, vibration of polyatomic molecules, Normal vibration and normal modes, Vibrational-Rotational spectra – fine structures, Diatomic molecule as Non-rigid rotator (Anharmonic Oscillator), Thermal Distribution of Quantum States in Vibrational Bands, Interpretation of vibrational spectra. Applications of InfraRed Spectroscopy. (5 Lectures)

Molecular Electronic Spectra: Vibrational Structure of electric bands, Franck-Condon Principle, Vibrational Coarse Structure, Rotational fine structure of electronic vibrational transitions. Fort rat Diagram, Predissociation . (5 Lectures)

MODULE 3

Raman Spectra: Classical and quantum Theory, Rotational Raman spectra, Vibration-Rotation Raman Spectra, Structure determination using IR and Raman spectroscopy (XY_2 and XY_3).

Nuclear Magnetic Resonance Spectroscopy: Precession of Nucleus in Magnetic field, NMR spectra, Interpretation of NMR Spectra, Relaxation process, Spin Flip in NMR and the principle of resonance, Chemical shifts and coupling constants, ^1H and ^{13}C NMR spectroscopy, Advanced NMR techniques: 2D NMR, COSY, HSQC , MRI

Electron Spin Resonance Spectroscopy: Principle of ESR, Hyperfine Interactions and Qualitative Analysis, Information obtained form ESR Spectroscopy.

Mossbauer Spectroscopy: Principle of Mossbauer Spectroscopy, Apparatus, Resonance Fluorescence

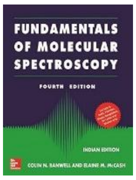
Fourier Infrared Spectroscopy: Fourier Series and Transformation, Operation of a Fourier Infrared Spectrometer. Sample Preparation and Measurement Techniques, Data Analysis and Interpretation,
X-ray Spectra: X-ray absorption Spectra, X-ray diffraction spectra, X-ray Fluorescence (XRF), X-ray Photoelectron Spectroscopy (XPS), Sample Preparation and Measurement Techniques, Data Analysis and Interpretation

5.0 DETAILED CONTENTS OF THE COURSE: PRACTICUM

Credit: 2 | **Laboratory Work: 60 Hours**

In the practicum component of the course, students will have to interpret dataset obtained from different types of spectroscopies.

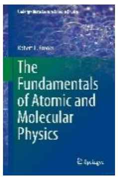
TEXT BOOKS



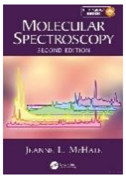
Name: Fundamentals of Molecular Spectroscopy
Author: Colin N. Banweel and Elaine M. McCash
Edition: 4th Ed.
Publisher: McGraw Hill Education
ISBN: 978-9352601738

Name: Atomic and Molecular Physics
Author: Raj Kumar
Edition:
Publisher: Kedar Nath Ram Nath
ISBN: 978-8180300356

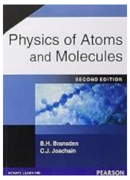
REFERENCE BOOKS AND MATERIALS



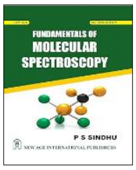
Name: The Fundamentals of Atomic and Molecular Physics
Author: Robert L Brooks
Edition: 2014
Publisher: Springer
ISBN: 9781461466789



Name: Molecular Spectroscopy
Author: Jeanne L. McHale
Edition: 2017
Publisher: CRC Press
ISBN: 9781466586611



Name: Physics of Atoms and Molecule
Author: B.H. Bransden and C. J. Joachain
Edition: 2nd Ed.
Publisher: Pearson Education India
ISBN: 978-8177582796



Name: Fundamentals Of Molecular Spectroscopy
Author: P.S. Sindhu
Edition: 2nd Ed.
Publisher: New Age Publishers
ISBN: 978-8122430608

6. Mapping of CLO to PO and PSO

The course outcomes and their mapping with program outcomes are specified in the table below

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CO2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

9.0 ASSESSMENT SCHEME

The evaluation system for this course consists of an 80% weightage on a comprehensive theory examination, which assesses students' understanding of various course topics, and a 20% weightage allocated to internal assessments, including internal examinations, assignments, class participation, and overall engagement in the course throughout the semester.

THEORY:

(A) Internal assessment: (20 marks): Continuous evaluation and internal assessment are implemented to foster and maintain a thorough understanding throughout the learning process. By regularly assessing comprehension through assignments, quizzes, and class participation, educators can address learning gaps promptly and support students in achieving deeper knowledge and proficiency in the subject matter.

(B) End-term examination (80 marks): The end-term examination serves as a culmination of students' learning in the course, assessing their comprehensive understanding and proficiency in various topics in the course. It provides a structured platform for students to demonstrate their knowledge, problem-solving abilities, and application of theoretical concepts, ultimately gauging their readiness to progress. Pattern of End term question paper

Section	Total Questions	Marks for each question	have to attempt	Total Marks
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C	4	15	2	30

PRACTICUM:

(A) Internal assessment: (20 marks): In the internal assessment of the practicum components, the student's performance, understanding, skills, sincerity, and involvement in laboratory work during the entire semester are evaluated.

(B) End-term examination (80 marks): The ability to apply theoretical knowledge to real-world situations is the fundamental criterion used in the End Term examination. It typically involves students' activity on randomly assigned laboratory works and the Laboratory Report (Notebook) on the performed work in the entire semester. In the End examination, the student must complete randomly assigned tasks and prepare a report on their work, including appropriate conclusions. The mark distribution for the End term examination as follows.

Activity	Marks
Laboratory work in the Examination	40
Laboratory Notebook	20
Presentation/Viva-voce	20

RESEARCH-BASED COURESES For FYUP in Physics(H)

PHY-001-RC-4110: RESEARCH METHODOLOGY

NCrF Level:	6.0	
Programme:	Four-Year Undergraduate Programme	**Semester:** Seventh
Course Category:	Minor (Research Based Course)	
Credit (L: T: P)	3: 0: 1	
Credit Hours	Theory: 45 Hours, Practicum: 30 Hours	

1.0 COURSE LEARNING OBJECTIVES

This course is an intensive exploration of design, execute, analysis, and ethically reporting research findings across various disciplines and contexts. The Learning Objectives of the course are:

- Gain a comprehensive understanding of research principles, including the purpose, process, and ethical considerations inherent in conducting research across diverse disciplines.
- Develop proficiency in designing and planning research projects and selecting appropriate methodologies for work ranging from experimental designs to qualitative methods.
- Cultivate critical thinking abilities to evaluate research literature, assess the validity of findings, and effectively communicate research outcomes through written reports.

2.0 COURSE LEARNING OUTCOME

After completing this course, students will be able to,

CO	Outcomes
CO1:	Understand the fundamentals of research and characteristics of research in Science as wewll as grasp the importance of research activities, and cultivate scientific attitudes,
CO2:	Understand the key concepts like induction, deduction, hypothesis, theory, law, and facts, and actives performed un academic Research in University in various programme.
CO3:	Learn the intersection of philosophy and science, analysing key concepts and epistemological frameworks, while evaluating paradigms and philosophical perspectives.
CO4:	Learn the rules and principles of the scientific method, formulate hypotheses, conduct hypothesis testing using various variables and requirements of experimental designs.
CO5:	Learn to identify research problems, plan research proposals, understand proposal formats, evaluate proposals, and explore sources of financial support.
CO6:	Develop expertise in literature survey techniques, library utilization, documentation methods, and use of online resources for comprehensive research.
CO7:	understand the structure of research reports and types of journal articles, gaining proficiency in writing research reports, synopses, and papers, and communicating with journals.
CO8:	Develop skills in writing literature review, information management, as well as understand the components and formatting of thesis and strategies for enhancing writing skills.

3.0 SKILLS TO BE LEARNED

- To design a research project, including formulating research questions or hypotheses,
- To conduct comprehensive literature reviews, identifying key studies, and synthesizing existing research
- To prepare research proposals and academic papers, including proper citation and referencing techniques.
- To communicate research findings through presentations, posters, and publications.

4.0 DETAILED CONTENTS OF THE COURSE: THEORY

Credit: 3 **Classroom Teaching: 45 Horus**

MODULE 1

Fundamentals of Research: Definition of Research, Characteristics, types, needs of research, Basic and Applied Research, Conceptual framework, General Characteristics of Modern Research, Relevant Research Topic, Research Design, Scientific Method in Research -S. R. Ranganathan's Spiral of Scientific Method, , Approaches to Research, Types and Classification of Research. Historical Research - constitutes of Historical Research, advantages and limitations, types and process of Historical Research; Survey Research - Library Survey, data collection – sampling, way of conducting survey research; Experimental Research - Experimentation, Research Procedure – sampling, Variety of experimental Research, Design of experiment – randomization, limitations of experimental method. **[7 hours]**

Perspectives of Scientific Research: Research in Science and Technology and its characteristics, Types of Research, importance of Research Activities, Principles of Quality Research Work, Problems in Research, Scientific Attitude and Scientific Temper, Qualities of good Researcher, Scientific Community, Non-science and Pseudoscience, Induction and Deduction in Research, Difference between Hypotheis, theory, law and facts, Research in Academic – undergraduate Research Work, improving academic Research, Research degree from universities **[4 hours]**

Philosophy and Science: Scientific Statement, Classical Approach, Empiricism – Hume's Problem of induction, Epistemology, Empiricism, Rationalism, Skepticism, Falsifiability, Positivism, Principle of Parsimony, Falsificationism – Duham problem, paradigm and paradigm shift (scientific revolution), Interpretivism and anti-positivism, Post-positivism, Relativism, Reductionism and Holism, Scientific Realism, Modernism and Postmodernism. **[4 hours]**

MODULE 2

Scientific Methodology: Rules and principles of Scientific method, Hypothesis – sources, types, characteristics of good Hypothesis. Testing a hypothesis – variables, correlations and causality, experimental and control groups, sampling, types of experimental design and its implementation, Classification of experiments, Requirements for good experiments. **[3 hours]**

Data Collection and Analysis: methods of data collection, principles of accessing research data, data processing and analysis, Null Hypothesis in statistical analysis – type I and type II errors, degrees of freedom, Error analysis – types, propagation of errors, significant figures, Scientific models. **[3 hours]**

Research Proposal – Finding a Research Problem, planning a Research Proposal, Format for Submitting Proposal, Evaluation procedure of Proposals, Sources of Financial Support**. [1 hours]**

Literature survey and documentation: Methods of literature survey, use of the library, books, journals, e-journals, thesis, chemical abstracts and patent database, importance of documentation, documentation techniques, use of computer programs/packages (online resources such as scientific search engines and online servers) in literature survey and documentation**. [3 hours]**

Developing a research plan and Literature survey: Aims and Objectives, information required for solving the problem, defining each major concept in operational terms: an overall description of approach, clearly stating any assumptions; details of techniques. Expected outcome, Methodology to be adapted, planning of experiments for achieving the aims and objectives, reproducibility of research work. Literature survey of the previous works Review of an article in the relevant field and preparation of a short report References, Abstraction of a research paper, possible ways of getting oneself abreast of current literature. **[5 hours]**

MODULE 3

Art of scientific writing : Importance and characteristics, Rules for Scientific Writings, effective scientific prose – Gopen and Swan's Guidelines, effective word selection, Scientific uses of tenses; Steps to better writing - flow method, organization of material and style; Structure of Research Report – Title, Abstract, Keywords, Introduction, Materials and Methods, Experimental work , theoretical study, figures, graphs, tables, results and discussion, conclusion, Acknowledgements, footnotes, references etc, **[6 hours]**

Research Report in Journals – Types of articles - Short Communication, Rapid Communication, Research Paper, Review Paper; Writing of Research Report and synopsis (steps involved), paper writing (steps involved), Interactive Journals; Communicating to Journal – electronic publication, submission methods, Selection of journals -peer review Impact Factor (JIF) , Citation Index, index, index, index **[5 hours]**

Literature Review – Importance of Literature Review, Planning and Relevant Literature Review, How to Manage Information, Academic and General Search Engines and online searching methods. Writing a Literature Review. **[2 hours]**

Research Thesis Writings: Components of a Research Thesis – preliminary pages, Thesis Abstract, formatting the thesis, arrangement of photo, figure, data tables, graphs and other illustrations, Reference management, how to improve writing skills – general guidelines and use of library. **[3 hours]**

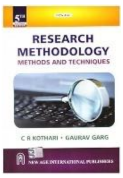
5.0 DETAILED CONTENTS OF THE COURSE: PRACTICUM

Credit: 2 **Laboratory Work: 30 Hours**

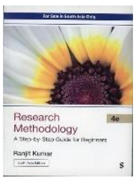
The practicum component of the Research Methodology students has to involved in designing, conducting, and analyzing research. This part of the course focus on applying theoretical concepts learned in lectures to practically. Students have collected data, and utilize various research methods and tools. The suggestive excesses for the students throughout the semester are

(a) Formulating research questions and hypotheses
(b) Designing a simple experiment, peer review of designs
(c) Prepare a literature review in a scientific way.
(d) Qualitative Data Collection and analysis
(e) Designing and conducting a survey or experiment
(f) Quantitative Data Collection and analysis
(g) Conducting a mock interview or focus group
(h) Writing research reports, creating presentations, data visualization
(i) Presenting research findings, peer review sessions

6.0 TEXT BOOKS



Name: Research Methodology
Author: C. R. Kothari
Edition: 5th Ed.
Publisher: New Age International Publishers
ISBN: 978-9389802559



Name: Research Methodology: A Step-by-Step Guide for Beginners
Author: Ranjit Kumar
Edition: 4th Ed.
Publisher: SAGE Publications Pvt. Ltd
ISBN: 978-9351501336

Name: Research Methodology and Scientific Writing
Author: C. George Thomas
Edition: 2018
Publisher: Ane Books Pvt. Ltd
ISBN: 978-9385462993

7.0 REFERENCE BOOKS AND MATERIALS

Name: Research Methodology: A Practical and Scientific Approach
Author: Mousami V. Munot, Vinayak Bairagi
Edition: 2019
Publisher: CRC Press
ISBN: 9781351013253

Name: Research Methodology: The Aims, Practices and Ethics of Science
Author: Peter Pruzan
Edition: 2016
Publisher: Springer
ISBN: 9783319271675

8.0 MAPPING OF CLO TO PO AND PSO

The course outcomes and their mapping with program outcomes are specified in the table below

Course Learning Outcomes	Programme Outcomes (POs)												Programme Specific Outcome (PSOs)					
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6
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CO2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

9.0 ASSESSMENT SCHEME

The evaluation system for this course consists of an 80% weightage on a comprehensive theory examination, which assesses students' understanding of various course topics, and a 20% weightage allocated to internal assessments, including internal examinations, assignments, class participation, and overall engagement in the course throughout the semester.

THEORY:

(A) Internal assessment: (20 marks): Continuous evaluation and internal assessment are implemented to foster and maintain a thorough understanding throughout the learning process. By regularly assessing comprehension through assignments, quizzes, and class participation, educators can address learning gaps promptly and support students in achieving deeper knowledge and proficiency in the subject matter.

(B) End-term examination (80 marks): The end-term examination serves as a culmination of students' learning in the course, assessing their comprehensive understanding and proficiency in various topics in the course. It provides a structured platform for students to demonstrate their knowledge, problem-solving abilities, and application of theoretical concepts, ultimately gauging their readiness to progress. Pattern of End term question paper

Section	Total Questions	Marks for each question	have to attempt	Total Marks
A	5	4	4	20
B	5	10	3	30
C	4	15	2	30

PRACTICUM:

(A) Internal assessment: (20 marks): In the internal assessment of the practicum components, the student’s performance, understanding, skills, sincerity, and involvement in laboratory work during the entire semester are evaluated.

(B) End-term examination (80 marks): The ability to apply theoretical knowledge to real-world situations is the fundamental criterion used in the End Term examination. In the End examination, the students have presented their work in the entire semester in front of the examination board. The mark distribution for the End term examination as follows.

Activity	**Marks**
Report on the work of the semester	40
Presentation/Viva-voce	30

PHY-001-RC-4210: RESEARCH AND PUBLICATION ETHICS

NCrF Level:	6.0	
Programme:	Four Year Undergraduate Programme	**Semester:** Eighth
Course Category:	Minor Course (Research Based Course)	
Credit (L: T: P)	2: 0: 2	
Credit Hours	Theory: 30 Hours, Practicum: 60 Hours	

1.0 COURSE LEARNING OBJECTIVES

The purpose of this course is to engage student researchers in reading about, understanding and discussing the responsible code of conduct of interdisciplinary scientific research. Specific learning objectives with respect to research ethics include:

- To know rules, issues, options, and resources for research ethics
- To familiarize with various institutional ethics review boards/academic integrity guidelines
- To understand the purpose and value of ethical decision-making
- To have a positive disposition towards continued learning about research ethics

2.0 COURSE LEARNING OUTCOME

After completing this course, students will be able to,

CO	Outcomes
CO1:	Critically analyze philosophical texts, apply ethical theories to real-world issues, and articulate informed perspectives on moral and philosophical problems.
CO2:	Develop the ability to identify, analyze, and address ethical issues in scientific research, ensuring integrity, objectivity, and compliance with professional standards.
CO3:	Develop the ability to identify, understand, and apply ethical principles in academic publishing, including plagiarism prevention, authorship integrity, conflict of interest management.
CO4:	Gain proficiency in recognizing, understanding, and implementing ethical standards for management, and sharing of research databases, ensuring data integrity, privacy.
CO5:	Learn to ethically analyze and use research metrics, applying them responsibly in assessing scholarly impact, while recognizing and mitigating their potential limitations and pitfalls.

3.0 SKILLS TO BE LEARNED

- To govern research integrity, including honesty, transparency,
- To identify and address ethical dilemmas that may arise during the research process,
- To make ethical decisions, including weighing competing ethical considerations
- To apply ethical frameworks and resolve various issues during research ethically.
- to uphold professional integrity and ethical behavior in all aspects of research and publication activities.

4.0 DETAILED CONTENTS OF THE COURSE: THEORY

Credit: 2 **Classroom Teaching: 30 Hours**

MODULE 1

Philosophy and Ethics:

- Introduction to philosophy, definition, nature and scope, concept, branches
- Ethics, definition, moral philosophy, nature of moral judgements and reactions

Scientific conduct:

- Ethics concerning science and research
- Intellectual honesty and research integrity
- Scientific misconduct, falsification, fabrication and plagiarism
- Redundant publications, duplicate and overlapping publications and salami slicing
- Selective reporting and misrepresentation of data idea of complex dielectric constant due to varying electric field. Boundary value problems with linear dielectrics. **(3 hours)**

Publication Ethics:

- Publication Ethics: definition, introduction and importance.
- Best practices – standards setting initiatives and guidelines: COPE, WAME, etc.
- Conflict of interest
- Publication misconduct: definition, concept, problems that lead to unethical
- behaviour and vice-versa, types.
- Violation of publication ethics, authorship and contributor ship
- Identification of publication misconduct, complaints and appeals
- Predatory publishers and journal
- Open access publications and initiatives
- SHERPA/RoMEO online resource to check publisher copyright and self-archiving policies;
- Software tool to identify predatory publications developed by SPPU
- Journal finder/journal suggestion tools, viz. JANE, Elsevier Journal Finder, Springer Journal Suggester, etc.

MODULE 2

Research Databases

- Overview of academic databases and search engines, Basic search techniques and strategies, Understanding search syntax and operators
- Advanced search techniques (Boolean operators, truncation, proximity searching), Evaluating search results and refining search queries, Citation searching and reference tracking
- Introduction to discipline-specific databases (e.g., PubMed, Web of Science, Scopus, PsycINFO), ands-on exercises in searching discipline-specific literature
- Overview of bibliographic management software (e.g., EndNote, Zotero, Mendeley), Organizing references and creating bibliographies, Importing and exporting references from databases

Research Metrics

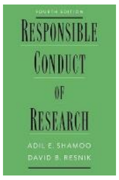
- Overview of research metrics and indicators, Citation analysis and bibliometrics, Limitations and controversies in using research metrics
- Understanding journal impact factors and related metrics, Evaluating journal quality and prestige, Alternative journal ranking systems (e.g., Eigenfactor, SJR)
- H-index, authorship networks, and collaboration indicators, Researcher profiles and academic social networks (e.g., Google Scholar Citations, ORCID), Researcher identifiers and disambiguation issues
- Research Metrics Analysis Tools - Hands-on workshop on using research metrics analysis tools (e.g., Web of Science, Scopus, Google Scholar), Analyzing citation patterns and citation networks

5.0 DETAILED CONTENTS OF THE COURSE: PRACTICUM

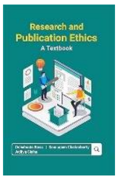
Credit: 2 **Laboratory Work: 60 Hours**

In the practicum component of this course, students will actively engage in designing, conducting, and analyzing research, while adhering to ethical principles and guidelines. This part of the course focuses on applying rules, issues, options, and resources for research ethics practically. In this component, Students are required to engage in an in-depth exploration of a specific area within physics by preparing a comprehensive review article. This task entails conducting thorough literature research to identify key studies, theoretical frameworks, and experimental findings relevant to the chosen topic. Students will critically evaluate and synthesize the gathered information to construct a coherent narrative that not only summarizes the current state of knowledge but also identifies gaps, unresolved questions, and emerging trends in the field. Through this process, students will develop advanced skills in academic writing, critical analysis, and scientific communication, preparing them to contribute effectively to scholarly discourse within their area of specialization.

TEXT BOOKS

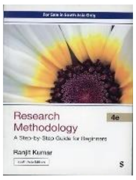


Name: Responsible Conduct of Research
Author: Adil E. Shamoo, David B. Resnik
Edition: 4th Ed. (2022)
Publisher: Oxford University Press Inc
ISBN: 978-0197547090

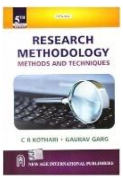


Name: Research and Publication Ethics: A Textbook
Author: Debabrata Basu; Samarpan Chakraborty and Aditya Sinha
Edition: 5th Ed.
Publisher: Concept Publishing Company Pvt. Ltd.
ISBN: 978-9354390852

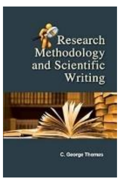
REFERENCE BOOKS AND MATERIALS



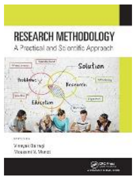
Name: Research Methodology: A Step-by-Step Guide for Beginners
Author: Ranjit Kumar
Edition: 4th Ed.
Publisher: SAGE Publications Pvt. Ltd
ISBN: 978-9351501336



Name: Research Methodology
Author: C. R. Kothari
Edition: 5th Ed.
Publisher: New Age International Publishers
ISBN: 978-9389802559



Name: Research Methodology and Scientific Writing
Author: C. George Thomas
Edition: 2018
Publisher: Ane Books Pvt. Ltd
ISBN: 978-9385462993



Name: Research Methodology: A Practical and Scientific Approach
Author: Mousami V. Munot, Vinayak Bairagi
Edition: 2019
Publisher: CRC Press
ISBN: 9781351013253

Name: Research Methodology: The Aims, Practices and Ethics of Science
Author: Peter Pruzan
Edition: 2016
Publisher: Springer
ISBN: 9783319271675

MAPPING OF CLO TO PO AND PSO

The course outcomes and their mapping with program outcomes are specified in the table below

Course Learning Outcomes	Programme Outcomes (POs)												Programme Specific Outcome (PSOs)					
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6
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CO2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

9.0 ASSESSMENT SCHEME

The evaluation system for this course consists of an 80% weightage on a comprehensive theory examination, which assesses students' understanding of various course topics, and a 20% weightage allocated to internal assessments, including internal examinations, assignments, class participation, and overall engagement in the course throughout the semester.

THEORY:

(A) Internal assessment: (20 marks): Continuous evaluation and internal assessment are implemented to foster and maintain a thorough understanding throughout the learning process. By regularly assessing comprehension through assignments, quizzes, and class participation, educators can address learning gaps promptly and support students in achieving deeper knowledge and proficiency in the subject matter.

(B) End-term examination (80 marks): The end-term examination serves as a culmination of students' learning in the course, assessing their comprehensive understanding and proficiency in various topics in the course. It provides a structured platform for students to demonstrate their knowledge, problem-solving abilities, and application of theoretical concepts, ultimately gauging their readiness to progress. Pattern of End term question paper

Section	Total Questions	Marks for each question	have to attempt	Total Marks
A	5	4	4	20
B	5	10	3	30
C	4	15	2	30

PRACTICUM:

(A) Internal assessment: (20 marks): In the internal assessment of the practicum components, the student's performance, understanding, skills, sincerity, and involvement in preparing the review article during the entire semester are evaluated.

(B) End-term examination (80 marks): The ability to apply theoretical knowledge to real-world situations is the fundamental criterion used for evaluation in the End Term examination. In the End examination, the students have presented their work in the entire semester in front of an external examiner. The mark distribution for the End term examination as follows.

Activity	Marks
Literature Search and Selection	10
Organization and Structure	10
Ethical Considerations	10
Writing style and clarity	10
Presentation and viva voce	40

VALUE ADDED COURESES

for FYUP in Physics(H)

PHY-001-VA-4220: INDIAN KNOWLEDGE SYSTEM: CONCEPTS AND APPLICATIONS IN SCIENCE

NCrF Level:	6.0	
Programme:	Four Year Undergraduate Programme	**Semester:** Eight
Course Category:	Value Added Course for Physics students	
Credit (L: T: P)	2: 0: 0	
Credit Hours	Theory: 30 Hours	

1.0 COURSE LEARNING OBJECTIVES

The Learning objectives of this course is

(a) To facilitate the students with the concepts of Indian traditional knowledge and to make them understand the importance of roots of Indian Knowledge System.

(b) To make students acquaint with the facets of traditional knowledge & their relevance and help them be able to apply it to their day-to-day life

2.0 COURSE LEARNING OUTCOME

After completing this course, students will be able to,

CO	Outcomes
CO1:	Provide an overview of the concept of the Indian Knowledge System and its importance
CO2:	Appreciate the need and importance of protecting traditional knowledge.
CO3:	Recognize the relevance of Traditional knowledge in different domains
CO4:	Establish the significance of Indian Knowledge systems in the contemporary world

3.0 SKILLS TO BE LEARNED

- To Explore the applications of traditional Indian scientific principles in contemporary science and technology, including mathematics, astronomy, medicine, and environmental science.
- to integrate IKS with modern scientific approaches for innovative problem-solving and sustainable practices.

4.0 DETAILED CONTENTS OF THE COURSE: THEORY

Credit: 3 **Classroom Teaching: 45 Horus**

MODULE 1

Indian Civilization and Development of Knowledge System: Genesis of the land, Antiquity of civilization, On the Trail of the Lost River, Discovery of the Saraswatī River, the Saraswatī-Sindhu Civilization, Traditional Knowledge System, The Vedas, Main Schools of Philosophy (6+3), Ancient Education System, the Takṣaśilā University, the Nālandā University, Alumni, Knowledge Export from Bhārata.

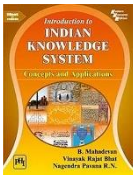
Indian Mathematics: Numbers, fractions and geometry in the Vedas. Decimal nomenclature of numbers in the Vedas. Zero and Infinity. Simple constructions from Sulba-sutras. The development of the decimal place value system which resulted in a simplification of all arithmetical operations. Linguistic representation of numbers. Important texts of Indian mathematics. Brief introduction to the development of algebra, trigonometry and calculus. How Indian mathematics continued to flourish in the 18/19/20th centuries. Kerala School. Ramanujan.

MODULE 2

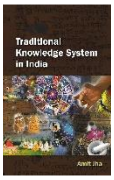
Indian Astronomy: Ancient records of the observation of the motion of celestial bodies in the Vedic corpus. Sun, Moon, Nakshatra & Graha. Astronomy as the science of determination of time, place and direction by observing the motion of the celestial bodies. The motion of the Sun and Moon. Motion of equinoxes and solstices. Elements of Indian calendar systems as followed in different regions of India. Important texts of Indian Astronomy. Basic ideas of the planetary model of Aryabhata and its revision by Nilakantha. Large corpus of inscriptions recording observation of eclipses. Astronomical instruments. How Indian astronomy continued to flourish in the 18/19th centuries. Astronomical endeavors of Jaisingh, Sankaravarman, Chandrasekhara Samanta

Indian Health Sciences: Vedic foundations of Ayurveda. Ayurveda is concerned both with maintenance of good health and treatment of diseases. Basic concepts of Ayurveda. The three Gunas and Three Doshas, Pancha-mahabhuta and Sapta-dhatu. The importance of Agni (digestion). Six Rasas and their relation to Doshas. Ayurvedic view of the cause of diseases. Dinacharya or daily regimen for the maintenance of good health. Ritucharya or seasonal regimen. Important Texts of Ayurveda. Selected extracts from Astāngahrdaya (selections from Sūtrasthāna) and Suśruta-Samhitā (sections on plastic surgery, cataract surgery and anal fistula). The large pharmacopeia of Ayurveda. Charaka and Sushruta on the qualities of a Vaidya. The whole world is a teacher of the good Vaidya. Charaka’s description of a hospital. Hospitals in ancient and medieval India. How Ayurveda continued to flourish till the 18/19th centuries. Surgical practices, inoculation. Current revival of Ayurveda and Yoga.

TEXT BOOKS

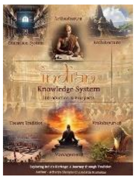


Name: Introduction to Indian Knowledge System: Concepts and Applications.
Author: B. Mahadevan, Nagendra Pavana, Vinayak Rajat Bhat
Edition: 4th Ed.
Publisher: PHI Learning
ISBN: 978-9391818203

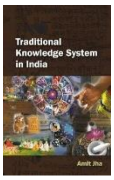


Name: Traditional Knowledge System In India
Author: Amit Jha
Edition: 2024
Publisher: Atlantic
ISBN: 978-8126912230

REFERENCE BOOKS AND MATERIALS



Name: Indian Knowledge System - Introducton & Prospects
Author: Acharya Shreyas Kurhekar
Edition: 2024
Publisher: H.V.P. Mandal Publication, Amaravati, Maharashtra
ISBN: 978-8197317330



Name: Traditional Knowledge System In India
Author: Amit Jha
Edition: 2024
Publisher: CRC Press
ISBN: 978-8126912230

6. MAPPING OF CLO TO PO AND PSO

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CO3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

9.0 ASSESSMENT SCHEME

The evaluation system for this course consists of an 80% weightage on a comprehensive theory examination, which assesses students' understanding of various course topics, and a 20% weightage allocated to internal assessments, including internal examinations, assignments, class participation, and overall engagement in the course throughout the semester.

THEORY:

(A) Internal assessment: (20 marks): Continuous evaluation and internal assessment are implemented to foster and maintain a thorough understanding throughout the learning process. By regularly assessing comprehension through assignments, quizzes, and class participation, educators can address learning gaps promptly and support students in achieving deeper knowledge and proficiency in the subject matter.

(B) End-term examination (80 marks): The end-term examination serves as a culmination of students' learning in the course, assessing their comprehensive understanding and proficiency in various topics in the course. It provides a structured platform for students to demonstrate their knowledge, problem-solving abilities, and application of theoretical concepts, ultimately gauging their readiness to progress. Pattern of End term question paper

Section	Total Questions	Marks for each question	have to attempt	Total Marks
A	5	4	4	20
B	5	10	3	30
C	4	15	2	30

MAJOR COURSES

Departmental Elective Courses

PHY - 001- DE - 42110: ADVANCED MATHEMATICAL PHYSICS

NCrF Level: 4.5
Programme: Four Year Undergraduate Programme **Semester:** 7th
Course Category: Major (Departmental Electives)
Credit (L: T: P) 3: 0: 2
Credit Hours Theory: 45 Hours, Practicum: 60 Hours

1.0 COURSE LEARNING OBJECTIVES

This course aims to equip students with a deep understanding of advanced mathematical physics, enabling them to apply these concepts to various physical and interdisciplinary problems. The Learning objectives of the course are:

- Understand and apply the fundamentals of vector spaces, including bases, dimensions, and linear transformations to physical problems.
- Master tensor notation, transformation properties, and applications in areas such as classical mechanics and general relativity.
- Become proficient in solving integral equations using analytical and numerical methods, and apply these techniques to potential theory, wave propagation, and quantum mechanics.
- Enhance research and problem-solving skills, effectively communicate complex mathematical concepts, and collaborate on challenging projects.

2.0 COURSE LEARNING OUTCOME

After completing this course, students will be able to,

CO	Outcomes
CO1:	Understand the fundamentals of linear vector spaces, including bases, dimensions, and linear transformations, and apply these concepts to physical problems.
CO2:	understand the properties and types of linear operators and will be able to apply these concepts to solve physical problems and analyze transformations in quantum mechanics and other fields.
CO3:	Understand the notation, operations, and transformation properties of Cartesian tensors and be able to apply them to solve problems in classical mechanics and electromagnetism.
CO4:	Learn the algebra, transformation properties, and applications of general tensors, and to use them to solve complex problems in areas like continuum mechanics and general relativity.
CO5:	proficient in solving various types of integral equations using analytical and numerical methods and will be able to apply these techniques
CO6:	Learn to solve integral equations using analytical methods such as separation of variables and numerical methods like discretization techniques.
CO7:	
CO8:	
CO9:	
CO10:	
CO11:	

3.0 SKILLS TO BE LEARNED

- Apply these concepts of linear algebra to solve problems in physics, and other disciplines.
- Apply tensors to describe physical quantities in various fields like mechanics, electromagnetism, and continuum mechanics.
- Apply integral equation techniques to model and solve problems in potential theory, wave propagation, quantum mechanics, and other areas of physics.

4.0 DETAILED CONTENTS OF THE COURSE: THEORY

Credit: 3 **Classroom Teaching: 45 Horus**

MODULE 1

Linear Vector Spaces: Binary Operations and Relations. Introduction to Groups and Fields. Vector Spaces and Subspaces. Linear Independence and Dependence of Vectors. Basis and Dimensions of a Vector Space. Change of basis. Homomorphism and Isomorphism of Vector Spaces. Linear Transformations. Algebra of Linear Transformations. Non-singular Transformations. Representation of Linear Transformations by Matrices. Linear operators. Commutator of operators. Orthogonal and unitary operators and their matrix representations. Adjoint of a linear operator. Hermitian operators and their matrix representation. Cayley-Hamilton Theorem. Diagonalization of Matrices. Solution of Coupled Linear Ordinary Differential Equations. Functions of a Matrix. **[15 Hours]**

MODULE 2

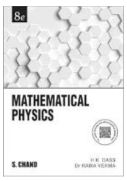
Cartesian Tensors: Vector Algebra and Calculus using Cartesian Tensors: Scalar and Vector Products, Scalar and Vector Triple Products. Differentiation. Gradient, Divergence and Curl of Tensor Fields. Tensor notation of Laplacian operator. Proof of Vector Identities involving scalar and vector products and vector identities involving Del operator under Tensor notation. Isotropic Tensors (Definition only). Tensorial Character of Physical Quantities. Moment of Inertia Tensor. Stress and Strain Tensors: Symmetric Nature. Elasticity Tensor. Generalized Hooke's Law. **[12 Hours]**

General Tensors: Minkowski Space. Contravariant & Covariant Vectors. Contravariant, Covariant and Mixed Tensors. Kronecker Delta and Permutation Tensors. Metric Tensor. **[3 Hours]**

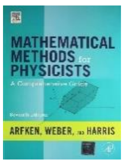
MODULE 3

Integral Equation: General classification of integral equations, Volterra and Fredholm equations of first and second kind, linear, non-linear and homogeneous equations, advantages of integral equations over differential equations, transformation of differential equation to integral equations, example - Schröndinger equation, linear harmonic oscillator equation. Solution of integral equations: Iterative technique (successive approximation or Neumann series), separable kernels (degenerate kernel), eigenvalue and eigenfunction problem, Fredholm method of solution, resolvent kernel (reciprocal kernel) in method of successive approximation, illustrative examples with problems and solutions **[15 Hours]**

TEXT BOOKS

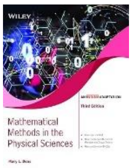


Name: Mathematical Physics
Author: H.K. Dass and R. Verma
Edition:8th Ed. (2022)
Publisher: S. Chand & Company.
ISBN: 978-9352837229

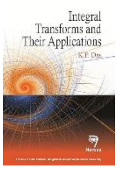


Name: Mathematical Methods for Physicists,
Author: G.B. Arfken, H.J. Weber, F.E. Harris
Edition: 7th Edn
Publisher: Elsevier
ISBN: 978-9381269558

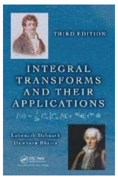
REFERENCE BOOKS AND MATERIALS



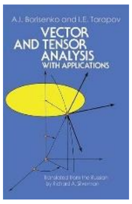
Name: Mathematical Methods in the Physical Sciences
Author: M. L. Boas, A.P.Singh, K. Mondal, M.S. Anand
Edition: 3rd Ed.
Publisher: Wiley
ISBN: 978-9354644252



Name: Integral Transforms and Their Applications
Author: K P Das
Edition: 2019
Publisher: Narosa Publishing House
ISBN: 978-8184876819



Name: Integral Transforms and Their Applications
Author: Lokenath Debnath and Dambaru Bhatta
Edition: 3rd Ed.
Publisher: Chapman and Hall/CRC
ISBN: 978-1482223576



Name: Vector and Tensor Analysis with Applications: Studies in Logic and the Foundation of Mathematics
Author: A. I. Borisenko
Edition: 2003
Publisher: Dover Publications Inc.
ISBN: 978-0486638331

6.0 MAPPING OF CLO TO PO AND PSO

The course outcomes and their mapping with program outcomes are specified in the table below

Course Learning Outcomes	Programme Outcomes (POs)												Programme Specific Outcome (PSOs)					
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6
CO1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

9.0 ASSESSMENT SCHEME

The evaluation system for this course consists of an 80% weightage on a comprehensive theory examination, which assesses students' understanding of various course topics, and a 20% weightage allocated to internal assessments, including internal examinations, assignments, class participation, and overall engagement in the course throughout the semester.

THEORY:

(A) Internal assessment: (20 marks): Continuous evaluation and internal assessment are implemented to foster and maintain a thorough understanding throughout the learning process. By regularly assessing comprehension through assignments, quizzes, and class participation, educators can address learning gaps promptly and support students in achieving deeper knowledge and proficiency in the subject matter.

(B) End-term examination (80 marks): The end-term examination serves as a culmination of students' learning in the course, assessing their comprehensive understanding and proficiency in various topics in the course. It provides a structured platform for students to demonstrate their knowledge, problem-solving abilities, and application of theoretical concepts, ultimately gauging their readiness to progress. Pattern of End term question paper

Section	Total Questions	Marks for each question	have to attempt	Total Marks
A	5	4	4	20
B	5	10	3	30
C	4	15	2	30

PHY - 001- DE - 42130: BASIC ASTRONOMY

NCrF Level:	6.5		
Programme:	Four Year Undergraduate Programme	**Semester:**	Eight
Course Category:	Major Course (Departmental Elective)		
Credit (L: T: P)	3: 0: 1		
Credit Hours	Theory: 45 Hours, Practicum: 30 Hours		

1.0 COURSE OBJECTIVES

The Learning Objectives of the course are:

- To introduce undergraduate students to understand how astronomers over millennia have come to understand mysteries of the universe using laws of geometry and physics.
- To introduce to the Indian contribution to astronomy starting from ancient times up to the modern era.
- To learn about diverse set of astronomical phenomena from the daily and yearly motion of stars and planets in the night sky which they can observe themselves.

2.0 COURSE LEARNING OUTCOME

After completing this course, students will be able to,

CO	Outcomes
CO1:	Historical development of astronomy in India and world and diurnal and yearly motion of astronomical objects, astronomical coordinate systems and their transformations.
CO2:	Brightness scale and measurements for stars, types of stars on HR diagram and how the distance, radiation of stars can be understood and measured.
CO3:	Gain of various types of astronomical telescopes and how the astronomical telescopes work and developments and working of current telescope projects in the world.
CO4:	classifications of galaxies under Hubble's classification.
CO5:	Knowledge on how the active galaxies is formed and studied.
CO6:	Understanding of the unified Model of the Various Active Galaxies and how to understand astronomical objects' parameters using programming language.
CO7:	
CO8:	
CO9:	
CO10:	

3.0 SKILLS TO BE LEARNED

- Historical development of astronomy and telescopes are to be learned.
- Skills for knowing heavenly body's phenomena are to be learned.
- Skills for identifying the naturally occurring mysterious phenomena are to be learned.
- The knowledge of the radiation sources of heavenly bodies are to be learned.

4.0 DETAILED CONTENTS OF THE COURSE: THEORY

Credit: 3 **Classroom Teaching: 45 Hours**

MODULE 1

Astronomy through ages: Early development of astronomy-first astronomers and renaissance, technology revolution, telescopes, space telescopes, photography, electronics and computers, non-optical astronomy, interplay of observation and theory, stars and nebulae, galaxies and the universe. [**5 lectures]**

Astrometry: Coordinate Systems-Horizontal system, equatorial coordinate system, ecliptic system, galactic coordinate system, super galactic coordinate system; space velocity and proper motion of stars-Doppler effect, parallax, and aberration. [**5 lectures]**

MODULE 2

Photometry: Flux Density and Intensity, Blackbody Radiation, Energy Density in an Isotropic Radiation Field, Magnitude, Apparent Magnitude, Absolute Magnitude, Colour Index, Bolometric Magnitude**. [5 lectures]**

Radiation from Astronomical Sources: Continuous Spectra-Synchrotron Radiation, Bremsstrahlung, Compton Scattering, Bound-Free Transitions; Absorption and Emission Line Spectrum-Radial Velocity Due to Doppler Effect, Causes of Finite Width of Spectral Lines. [**10 lectures]**

Astronomical Instruments: Observing through the atmosphere (Scintillation, Seeing, Atmospheric Windows and Extinction). Basic Optical Definitions for Telescopes: Magnification, Light Gathering Power, Limiting magnitude, Resolving Power, Diffraction Limit. Optical telescopes, radio telescopes, Hubble space telescope, James Web space telescope, Fermi Gamma ray space telescope. Astronomy in the Internet Age: Overview of Aladin Sky Atlas, Sloan Digital Sky Survey, Stellarium. **[5 hours]**

MODULE 3

Stellar structure: Hydrostatic Equilibrium of a Star, Some Insight into a Star: Virial Theorem, Sources of Stellar Energy, Modes of Energy Transport, Simple Stellar Model, Polytropic Stellar Model. Star formation: Basic composition of Interstellar medium, Interstellar Gas, Interstellar Dust, Formation of Protostar, Jeans criterion, Fragmentation of collapsing clouds, From protostar to Pre-Main Sequence, Hayashi Line. **[5 hours]**

Galaxies: Galaxy Morphology, Hubble's Classification of Galaxies, Elliptical Galaxies (The Intrinsic Shapes of Elliptical, de Vaucouleurs Law, Stars and Gas). Spiral and Lenticular Galaxies (Bulges, Disks, Galactic Halo) The Milky Way Galaxy, Gas and Dust in the Galaxy, Spiral Arms, Active Galaxies **(3 Lectures)**

Active galaxies: 'Activities' of Active Galaxies, How 'Active' are the Active Galaxies? Classification of the Active Galaxies, Some Emission Mechanisms Related to the Study of Active Galaxies, Behaviour of Active Galaxies (Quasars and Radio Galaxies, Seyferts, BL Lac Objects and Optically Violent Variables), The Nature of the Central Engine, Unified Model of the Various Active Galaxies **[7 hours]**

5.0 DETAILED CONTENTS OF THE COURSE: PRACTICUM

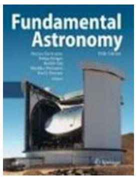
Credit: 1 **Laboratory Work: 60 Hours**

Lists of Experiments/problems to be performed in Python/Scilab whichever is necessary.

1. Write a program to determine the problems on Coordinate Systems-Horizontal system, equatorial coordinate system.
2. Write a program to determine the conversion problems on ecliptic system, galactic coordinate system, super galactic coordinate system.
3. Write a program to determine the distances of the celestial objects' problems on space velocity and proper motion of stars-Doppler effect, parallax, and aberration.

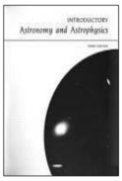
4. Write and execute a program on Flux Density and Intensity, Blackbody Radiation, Energy Density in an Isotropic Radiation Field of given sources.
5. Write and execute a program on Magnitude, Apparent Magnitude, Absolute Magnitude, Color Index, Bolometric Magnitude of given sources.
6. Write a program and execute the problems based on telescopes' resolution, aperture, magnification with references to some sources.
7. Write a program and execute the problems based on Continuous Spectra-Synchrotron Radiation, Bremsstrahlung, Compton Scattering.
8. Write a program and execute the problems based on Bound-Free Transitions; Absorption and Emission Line Spectrum-Radial Velocity Due to Doppler Effect, Causes of Finite Width of Spectral Lines.
9. Write a program to execute the problems on the polytropic stellar model.
10. Write and execute the problems based on the galaxy potential.
11. Classify and determine the luminosity of active galaxy with available observational data.

TEXT BOOKS



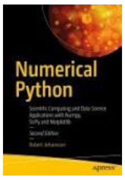
Name: Fundamental Astronomy
Author: Hannu Karttunen, Heikki Oja, Karl Johan Donner, Markku Poutanen, Pekka **Kröger**
Edition: 4th Edition
Publisher: Springer Berlin Heidelberg
ISSN: 9783662053331

Name: The Physical Universe: An Introduction to Astrophysics
Author: Frank Shu
Edition: First Edition (1982)
Publisher: University Science Books
ISSN: 9780935702057

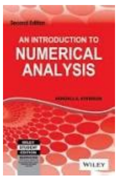


Name: Introductory astronomy and astrophysics
Author: Michael Zeilik, Stefan A. Gregory, Elske Van Panhuys Smith
Edition: Second Edition (1992)
Publisher: Saunders College Pub.
ISSN: 9780030316975

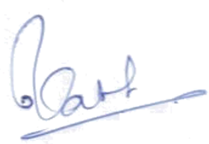
REFERENCE BOOKS AND MATERIALS

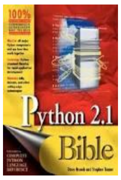


Name: Numerical Python
Author: Robert Johansson
Edition: First Edition (2018)
Publisher: Apress
ISSN: 9781484242469

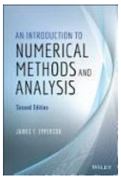


Name: An Introduction to Numerical Analysis
Author: Kendall E. Atkinson
Edition: Second Edition (2008)
Publisher: Wiley India Pvt. Limited
ISSN: 9788126518500

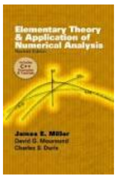




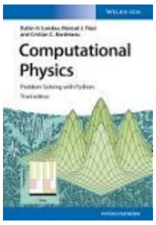
Name: Python 2.1 Bible
Author: Dave Brueck, Stephen Tanner
Edition: First Edition (2001)
Publisher: Wiley
ISSN: 9780764548079



Name: An Introduction to Numerical Methods and Analysis
Author: James F. Epperson
Edition: First Edition (2013)
Publisher: Wiley
ISSN: 9781118367599



Name: Elementary Theory and Application of Numerical Analysis
Author: David G. Moursund, James E. Miller, Chares S. Duris
Edition: First Edition (2013)
Publisher: Dover Publications
ISSN: 9780486310398



Name: Ele **Computational Physics problem solving with Python**
Author: Rubin H. Landau, Manuel J. Paez, Cristian C. Bordeianu
Edition: First Edition (2015)
Publisher: Wiley
ISSN: 9783527413157

6.0 MAPPING OF CLO TO PO AND PSO

The course outcomes and their mapping with program outcomes are specified in the table below

Course Learning Outcomes	Programme Outcomes (POs)												Programme Specific Outcome (PSOs)					
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6
CO1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

9.0 ASSESSMENT SCHEME

The evaluation system for this course consists of an 80% weightage on a comprehensive theory examination, which assesses students' understanding of various course topics, and a 20% weightage allocated to internal assessments, including internal examinations, assignments, class participation, and overall engagement in the course throughout the semester.

THEORY:

(A) Internal assessment: (20 marks): Continuous evaluation and internal assessment are implemented to foster and maintain a thorough understanding throughout the learning process. By regularly assessing comprehension through assignments, quizzes, and class participation, educators can address learning gaps promptly and support students in achieving deeper knowledge and proficiency in the subject matter.

(B) End-term examination (80 marks): The end-term examination serves as a culmination of students' learning in the course, assessing their comprehensive understanding and proficiency in various topics in the course. It provides a structured platform for students to demonstrate their knowledge, problem-solving abilities, and application of theoretical concepts, ultimately gauging their readiness to progress. Pattern of End term question paper

Section	Total Questions	Marks for each question	have to attempt	Total Marks
A	5	4	4	20
B	5	10	3	30
C	4	15	2	30

PRACTICUM:

(A) Internal assessment: (20 marks): In the internal assessment of the practicum components, the student's performance, understanding, skills, sincerity, and involvement in laboratory work during the entire semester are evaluated.

(B) End-term examination (80 marks): The ability to apply theoretical knowledge to real-world situations is the fundamental criterion used in the End Term examination. It typically involves students' activity on randomly assigned laboratory works and the Laboratory Report (Notebook) on the performed work in the entire semester. In the End examination, the student must complete randomly assigned tasks and prepare a report on their work, including appropriate conclusions. The mark distribution for the End term examination as follows.

Activity	Marks
Laboratory work in the Examination	40
Laboratory Notebook	20
Presentation/Viva-voce	30

PHY - 001- DE - 42140 : BASIC ASTROPHYSICS

NCrF Level:	4.5	
Programme:	Four Year Undergraduate Programme	**Semester:** Eight
Course Category:	Major Course (Departmental Electives)	
Credit (L: T: P)	3: 0: 1	
Credit Hours	Theory: 45 Hours, Practicum: 30 Hours	

1.0 COURSE OBJECTIVES

The Learning Objectives of the course are:

- The students are expected to understand the fundamentals, principles, physical concepts and recent developments in the Astrophysics area.
- It is expected to inspire and boost interest of the students towards Astrophysics as the interdisciplinary subject.
- To develop the power of appreciations, the achievements in Astrophysics and role in nature and society.
- To enhance student sense of enthusiasm for Astrophysics and to involve them in an intellectually stimulating experience of Course in a supportive environment.

2.0 COURSE LEARNING OUTCOME

After completing this course, students will be able to,

CO	Outcomes
CO1:	Understand the fundamentals in the Astrophysics and learn the laws of planetary motions acquired in the classroom and conservations of quantities.
CO2:	Understand the spatial velocities of the Stars, Oort's constant determination and distance measurements of galaxies.
CO3:	Familiarize with the basic principles and theories of new emerging area of astrophysics.
CO4:	Equip the Ptolematic and Copernican worldviews leading to present world views and demonstrate the ability to link observation and theory.
CO5:	Learn theoretical and practical aspects of modern astrophysics.
CO6:	Study the importance of stellar populations and their formations and classification.
CO7:	
CO8:	
CO9:	

3.0 SKILLS TO BE LEARNED

- How to know the astrophysical phenomena is to be learned.
- Mechanisms of stellar structure and galaxy structure are to be learnt.
- How to realize and understand the astronomical problems is to be learnt in the light of mechanics.

4.0 DETAILED CONTENTS OF THE COURSE: THEORY

Credit: 3 **Classroom Teaching: 45 Horus**

MODULE 1

Mechanics and Gravitational Theory:
Newton's laws of motion and gravitation, Gravitational Energy, Conservation of Linear Momentum, Conservation of Angular Momentum, the Area Theorem, Conservation of Energy, The Virial Theorem. [**10 lectures]**

MODULE 2

Celestial Mechanics:

Kepler's First and Second Laws-Planetary Orbits, Kepler's Third Law: -Determination of Masses, Conservation of Energy and the Escape Velocity, Rotation and the Moment of Inertia, Precession, Tidal Forces and Roche Limit, The Ptolemaic and the Copernican Worldviews. [**10 lectures]**

MODULE 3

Fundamental Equations of Stellar Structure:
Hydrostatic Equilibrium and the Equation of State of Matter, Temperature Distribution and Energy Transport, Energy Production Through Nuclear Reactions, Gravitational Energy and Thermal Energy, Stability of the Stars. [**15 lectures]**
Stars and the Structure of galaxy:
Galactic Coordinates, Oort constants and derivation, Star Gauging, Spatial Velocities of the Stars, Star Clusters: Distance Determinations and the Structure of galaxy (e.g. the Milky Way). [**10 lectures]**

5.0 DETAILED CONTENTS OF THE COURSE: PRACTICUM

Credit: 1 **Laboratory Work: 30 Hours**

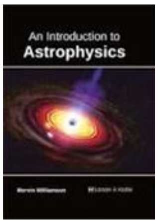
Lists of Experiments/problems to be performed in Python/Scilab whichever is necessary.

1. Review on finding root finding for a single variable (basic theory and algorithm) in programming language by
   - Bisection method
   - Newton-Raphson Method
2. ODE in one- and two-dimensions using Euler algorithm (output to be saved in data files)
   - Particle dynamics in 1D
3. Write a program to solve the equation of motion for the Two-Body Problem and hence plot for its trajectory.
4. Write a program to solve the equation of motion for the three-Body Problem: Neptune, Two Suns, Stars; two fixed suns with a single planet; Henon-Helles bound states and hence plot for its trajectory.
5. Consider the flat, conducting, circular disk of radius R. The disk is kept at a constant potential V and has a mass density ρ ∝(R2 - ρ2)-1/2, where ρ is the radial distance from the center of the disk. Determine the potential and write a program that creates a polar plot of the potential at fixed values of *r* and *φ* as a function of the polar angle *ϑ*. Make the plot for several values of *r*.Now create some surface plots of the potential *U*(*r, ϑ, φ*). Take note that the potential is symmetric with respect to *φ*, so in a sense you will be rotating the polar plots. Compare the analytic solution given above to a numeric one that solves Laplace's or Poisson's equation using finite differences and relaxation. How do the two compare?
6. Consider the interaction between the two charged, spinless particles. The relativistic two-body problem has its difficulties and is usually treated only approximately. To this end, Jackson derives the Darwin Lagrangian describing the interaction between two charged particles correct to order 1/*c*^2. The equations of motion are derived from the Lagrangian in the usual way, which we write in several forms. Consider two charges initially separated by a distance *r*. Since we start off with a

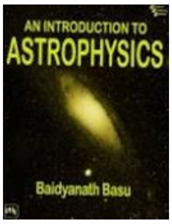
symmetrical configuration for both charges, and since the equations of motion are symmetric, assume that the paths of the charges remain symmetric. Program up the equation of motion so that you can solve it with a standard ODE solver.

7. Write a program to perform the Escape Velocity, Rotation and the Moment of Inertia, Precession, Tidal Forces and Roche limit, The Ptolemaic and the Copernican Worldviews.
8. Write a program to determine the temperature Distribution function and to plot Energy Transport.
9. Write a program to solve the Energy Production through Nuclear Reactions equations and to plot Energy Transport, Energy Production through Nuclear Reactions.
10. Write a program to evaluate Gravitational Energy and Thermal Energy, Stability of the Stars.

6.0 TEXT BOOKS

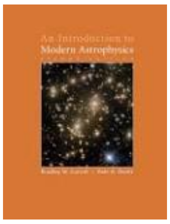


Name: An Introduction to Astrophysics
Author: Mervin Williamson
Edition: Second Edition (2017)
Publisher: Larsen and Keller Education
ISBN: 9781635490343

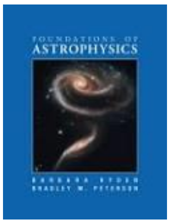


Name: An Introduction to Astrophysics
Author: Baidyanath Basu, Tanuka Chattopadhyay, Sudhindra Nath Biswas
Edition: 2011 Edition
Publisher: PHI Learning
ISBN: 9788120340718

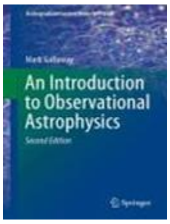
7.0 REFERENCE BOOKS AND MATERIALS



Name: An Introduction to Modern Astrophysics
Author: Bradley W. Carroll, Dale A. Ostlie
Edition: 2011 Edition
Publisher: Cambridge University Press
ISBN: 9781108422161



Name: Foundations of Astrophysics
Author: Barbara Ryden, Bradley M. Peterson
Edition: 2020 Edition
Publisher: Cambridge University Press
ISBN: 9781108831956



Name: An Introduction to Observational Astrophysics
Author: Mark Gallaway
Edition: 2020 Edition
Publisher: Springer International Publishing
ISBN: 9783030435516

8.0 MAPPING OF CLO TO PO AND PSO

The course outcomes and their mapping with program outcomes are specified in the table below

Course Learning Outcomes	Programme Outcomes (POs)												Programme Specific Outcome (PSOs)					
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6
CO1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

9.0 ASSESSMENT SCHEME

The evaluation system for this course consists of an 80% weightage on a comprehensive theory examination, which assesses students' understanding of various course topics, and a 20% weightage allocated to internal assessments, including internal examinations, assignments, class participation, and overall engagement in the course throughout the semester.

THEORY:

(A) Internal assessment: (20 marks): Continuous evaluation and internal assessment are implemented to foster and maintain a thorough understanding throughout the learning process. By regularly assessing comprehension through assignments, quizzes, and class participation, educators can address learning gaps promptly and support students in achieving deeper knowledge and proficiency in the subject matter.

(B) End-term examination (80 marks): The end-term examination serves as a culmination of students' learning in the course, assessing their comprehensive understanding and proficiency in various topics in the course. It provides a structured platform for students to demonstrate their knowledge, problem-solving abilities, and application of theoretical concepts, ultimately gauging their readiness to progress. Pattern of End term question paper

Section	Total Questions	Marks for each question	have to attempt	Total Marks
A	5	4	4	20
B	5	10	3	30
C	4	15	2	30

PRACTICUM:

(A) Internal assessment: (20 marks): In the internal assessment of the practicum components, the student's performance, understanding, skills, sincerity, and involvement in laboratory work during the entire semester are evaluated.

(B) End-term examination (80 marks): The ability to apply theoretical knowledge to real-world situations is the fundamental criterion used in the End Term examination. It typically involves students' activity on randomly assigned laboratory works and the Laboratory Report (Notebook) on the performed work in the entire semester. In the End examination, the student must complete randomly assigned tasks and prepare a report on their work, including appropriate conclusions. The mark distribution for the End term examination as follows.

Activity	Marks
Laboratory work in the Examination	40
Laboratory Notebook	20
Presentation/Viva-voce	20

PHY - 001- DE - 42150 : SPECIAL THEORY OF RELATIVITY

NCrF Level: 4.5

Programme: Four Year Undergraduate Programme **Semester:** Eight

Course Category: Major (Departmental Elective)

Credit (L: T: P) 3: 1: 0

Credit Hours Theory: 45 Hours, Tutorial: 15 Hours

1.0 COURSE OBJECTIVES

The course is aimed to impart the knowledge on the historical developments of special theory of relativity and its applications in day-to-day life.

The Learning Objectives of the course are:

- To understand the historical development and basic principles of the Special Theory of Relativity.
- To apply Lorentz transformation equations to space and time involving problems and relativistic kinematics.
- To analyze the implications of relativistic dynamics, including momentum and energy in different frames of reference.
- To impart the concepts of the scalar and vector fields in special relativity to the learners.
- To reach out the ideas of relativistic electrodynamics in various fields and its applications.

2.0 COURSE LEARNING OUTCOME

After completing this course, students will be able to,

CO	Outcomes
CO1:	gain knowledge of the historical developments of special theory of relativity and understand the meaning and significance of the postulates of special relativity.
CO2:	enable to apply the concepts of special relativity in various fields of science and realize the equivalence principle as a foundation for the development of the special theory of relativity.
CO3:	gain how the gravitational redshift happens in strong fields and expertise the implications of relativistic dynamics specially momentum and energy involving problems.
CO4:	realize the importance of tensor quantities as a result from the study of theory of relativity.
CO5:	realize the importance of tensor quantities as a result from the study of theory of relativity and gain the concepts of relativistic electrodynamics in various fields.
CO6:	learn how to manipulate the relativistic Lagrangian and Hamiltonian of a charged particle in an electromagnetic field.

3.0 SKILLS TO BE LEARNED

Major skills while learning and after the completion of this course are:

- He/she learns skills to understand the prior basic concepts of elementary mechanics and calculus.
- Skills for strong imaginations and how to tackle astronomical and relativity problems will be gained.
- Skills for what and how to tackle tensorial problems of relativities are to be learned.

4.0 DETAILED CONTENTS OF THE COURSE: THEORY

Credit: 3 **Classroom Teaching: 45 Horus**

MODULE 1

Introduction: Newtonian mechanics, Galilean relativity, Electrodynamics and inconsistency with Galilean relativity, Michelson-Morley experiments, Lorentz and Poincare's developments towards relativity **[5 lectures]**

Einstein's special theory-Postulates of special relativity, derivation of Lorentz transformation equations, consequences of special relativity, Minkowski space-time diagram boosts as complex rotations in Minkowski space, the relativistic force law and dynamics of a single particle.**[5 lectures]**

MODULE 2

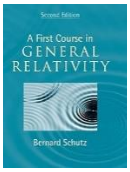
Scalar and electromagnetic fields in special relativity: External fields of force, action and dynamics of a particle interacting with a scalar field, charged particle in an electromagnetic field, motion in the Coulomb field and in a constant electric field. **[10 lectures]**

Relativistic electrodynamics: Transformations for charge and current density, transformations of electromagnetic potentials, Invariance of Maxwell field equations, Electromagnetic field tensor, Transformations of electric and magnetic fields, relativistic Lagrangian and Hamiltonian of a charged particle in an electromagnetic field**. [10 lectures]**

MODULE 3

Beyond special relativity: Principle of equivalence, principle of general covariance, criteria for gravitational field equations, Metric tensor and affine connection, gravity as a geometric Phenomenon, Gravitational potential as metric tensor, Einstein field equations and their classical limits, Laws of physics in presence of gravitation, gravitational time dilation and red shift, Experimental observation of gravitational red shift. **[15 lectures]**

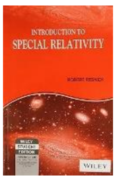
5.0 TEXT BOOKS



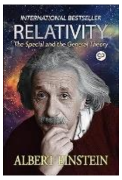
Name: First Course in General Relativity
Author: B.F. Schutz
Edition: 2009
Publisher: Cambridge University Press
ISBN: 978-0521887052

Name: Classical Theory of Fields (Course of Theoretical Physics Vol. 2)
Author: JL.D. Landau and E.M. Lifshitz
Edition: 1975
Publisher: Pergamon Press
ISBN: 978-0750627689

6.0 REFERENCE BOOKS AND MATERIALS



Name: Introduction to Special Relativity,
Author: R. Resnick,
Edition: 2005,
Publisher: John Wiley and Sons.
ISBN: 978-8126511006



Name: Relativity: The Special and the General Theory
Author: Albert Einstein
Edition: 2013
Publisher: General Press
ISBN: 978-9380914220

7.0 MAPPING OF CLO TO PO AND PSO

The course outcomes and their mapping with program outcomes are specified in the table below

Course Learning Outcomes	Programme Outcomes (POs)												Programme Specific Outcome (PSOs)					
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6
CO1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

9.0 ASSESSMENT SCHEME

The evaluation system for this course consists of an 80% weightage on a comprehensive theory examination, which assesses students' understanding of various course topics, and a 20% weightage allocated to internal assessments, including internal examinations, assignments, class participation, and overall engagement in the course throughout the semester.

THEORY:

(A) Internal assessment: (20 marks): Continuous evaluation and internal assessment are implemented to foster and maintain a thorough understanding throughout the learning process. By regularly assessing comprehension through assignments, quizzes, and class participation, educators can address learning gaps promptly and support students in achieving deeper knowledge and proficiency in the subject matter.

(B) End-term examination (80 marks): The end-term examination serves as a culmination of students' learning in the course, assessing their comprehensive understanding and proficiency in various topics in the course. It provides a structured platform for students to demonstrate their knowledge, problem-solving abilities, and application of theoretical concepts, ultimately gauging their readiness to progress. Pattern of End term question paper

Section	Total Questions	Marks for each question	have to attempt	Total Marks
A	5	4	4	20
B	5	10	3	30
C	4	15	2	30

PHY - 001- DE - 42160: ELECTRONIC INSTRUMENTATION

NCrF Level:	6.0	
Programme:	Four-Year Undergraduate Programme	**Semester:** Eight
Course Category:	Major Course (Departmental Elective)	
Credit (L: T: P)	2: 0: 2	
Credit Hours	Theory: 30 Hours, Practicum: 60 Hours	

1.0 COURSE LEARNING OBJECTIVES

This course aims to provide students with a comprehensive understanding of electronic instrumentation and its practical applications, which enable them to design, analyse, and troubleshoot electronic measurement systems. The learning objectives of this course are:

- To introduce the basic principles of electronic instrumentation.
- To familiarize with various types of electronic measuring instruments
- To provide the working principle and use of sensors in various laboratory experiments.
- To enable the design and analysis of electronic measurement systems.
- To introduce skills in data acquisition and processing techniques.
- To cultivate practical skills through laboratory experiments and hands-on projects.

2.0 COURSE LEARNING OUTCOME

After completing this course, students will be able to,

CO	Outcomes
CO1:	Learn the importance, classification, and characteristics of electronic measuring instruments as well as their accuracy, precision, resolution, and reliability.
CO2:	Understand the operation, and specification of different electronic instruments like voltameter, ammeter, ohmmeter and Multimeter and their use in various physics experiments.
CO3:	Understand the operation and components of cathode ray tubes and oscilloscopes and learn their use to analyse an electronic signal to measure amplitude, frequency, phase etc.
CO4:	Understand the operation and functionalities of special-purpose oscilloscopes, including dual trace, dual beam, sampling, storage, and digital storage CROs.
CO5:	Understand the operation and applications of the Wheatstone, Kelvin, Hay, Maxwell, Schering, and Wien bridges and Wagner ground connection.
CO6:	Understand the operation and characteristics of AF and RF signal generators as well as the use of spectrum analysers and frequency counters to analyse a complex electronic signal.
CO7:	Learn the working principles and characteristics of sensors and their use in the measurement of various physical parameters.
CO8:	Proficiency in designing, implementing, and troubleshooting data acquisition systems (DAS), encompassing the integration of transducers through different interfering circuits.
CO9:	Lean to write detailed and scientifically rigorous laboratory reports, including documentation of objectives, methodologies, data analysis, results, and conclusions

3.0 SKILLS TO BE LEARNED

- Proficiently operate and interpret readings from various electronic instruments and oscilloscopes
- Ability to analyze the accuracy, precision, resolution and reliability of electronic instruments
- Apply measurement standards, calibration techniques, and troubleshooting methods to ensure accurate and reliable instrument performance.
- Design and development of electronic measuring instruments using different types of sensors.

4.0 DETAILED CONTENTS OF THE COURSE: THEORY

Credit: 3 **Classroom Teaching: 45 Horus**

MODULE 1

Basics of Measurements: Overview of electronic instruments - Definition and importance of electronic instrumentation, Classification of measuring instruments, Characteristics of measuring instruments, Importance and applications. Accuracy, Precision, resolution, reliability, repeatability, validity of electronic instrumentations, Errors in electronic instruments - Types of Errors, analysis of errors, Dynamic Characteristics, Repeatability, Reproducibility, Fidelity, Lag, Standards of measurement. **[4 hours]**

Basic Electronic instruments: DC Voltmeters, D' Arsonval Movement, DC Current Meters, AC Voltmeters and Current Meters, Ohmmeters, Multimeter, Meter Protection, Extension of Range, True RMS Responding Voltmeters, Specifications of Instruments, Amplified DC meter, Electronic multi-meter, Digital voltmeter, Vector Voltmeter. **[4 hours]**

Oscilloscopes: Cathode Ray Tube, Vertical and Horizontal Deflection Systems, Block Schematic of CRO, Time Base Circuits, Lissajous Figures, CRO Probes, High-Frequency CRO Considerations, Delay lines, Probes and Transducers, Specification of an Oscilloscope. Oscilloscope measurement Techniques, Measurement of Time, Period and Frequency. Special Purpose Oscilloscopes: Dual Trace, Dual Beam CROs, Sampling Oscilloscopes, Storage Oscilloscopes, Digital Storage CROs. **[5 hours]**

Bridge Measurement: DC bridges- Wheatstone bridge, AC bridges – Kelvin, Hay, Maxwell, Schering and Wien bridges, Wagner ground Connection. **[2 hours]**

MODULE 2

Signal Generators and analyser: AF, RF Signal Generators, Sweep Frequency Generators, Pulse and Square wave Generators, Function Generators, Arbitrary waveform Generator, Sine wave generators, Analysis of signal - Wave Analyzer, Spectrum Analyzer. Frequency Counters: Simple Frequency Counter; Measurement errors; extending the frequency range of counters **[5 hours]**

Transducers, sensors and actuators: Classification of sensors based on physical principles, Types of actuators and their applications, resistive, capacitive, inductive, optical sensors, Principles of operation, Characteristics and selection criteria, Strain Gages, Displacement Transducers. , Bounded, unbounded; Force and Displacement Transducers, Resistance Thermometers, Hotwire Anemometers, LVDT, Thermocouples, Synchros, Special Resistance Thermometers, Piezoelectric Transducers, Magneto Strictive Transducers. **[5 hours]**

Data Acquisition Systems: Introduction to data acquisition systems (DAS), Interfacing transducers to Electronics Control and Measuring System Components of DAS (sensors, signal conditioning, analog-to-digital, Sampling theorem and aliasing**,** Interface Standards; Signal Conditioning in data acquisition-Amplification, Filtering, Analog-to-digital conversion, Instrumentation amplifiers and Signal Conditioning Circuits, Differential amplifiers, Bridge circuits for sensor interfacing, Noise reduction techniques **[5 hours]**

5.0 DETAILED CONTENTS OF THE COURSE: PRACTICUM

Credit: 2 **Laboratory Work: 60 Hours**

In the practical component of the course, students will undergo hands-on experience with various electronic measuring instruments Through a series of practical exercises, students will learn precise measurements of various electronic parameters. In the laboratory students also have to design and construct electronic circuits to measure different physical parameters. The suggestive list of experiments is

Basic electronic parameter measurements:

- Use a digital Multimeter and oscilloscope to measure DC and AC voltages in different circuits.
- Compare measurement accuracy and resolution between different instruments.
- Measure DC and AC currents using different methods such as shunt resistors and clamp meters.
- Evaluate the impact of different methods on circuit performance.
- Measure resistance using a digital Multimeter and Wheatstone bridge.
- Calculate resistance using Ohm's law and compare with measured values.
- Use a frequency counter and oscilloscope to measure the frequency and period of different signals.
- Analyze frequency and time-domain waveforms.

Sensor Calibration and Characterization:

- Calibrate and characterize different sensors such as temperature, pressure, and light sensors.
- Determine sensor sensitivity, linearity, and range.

Data Acquisition and Analog-to-Digital Conversion:

- Set up a data acquisition system using an ADC and microcontroller.
- Acquire and analyze data from different sensors and instruments.

Signal Conditioning and Filtering:

- Design and implement signal conditioning circuits such as amplifiers and filters for sensor outputs.
- Measure the effects of signal conditioning on signal quality and accuracy.

Digital Signal Processing:

- Perform digital signal processing on acquired data using software tools such as MATLAB or Python.
- Apply techniques such as Fourier analysis, filtering, and signal transformation.

Interfacing Instruments with Computers:

- Interface electronic instruments with a computer for automated measurements and data logging.
- Control instruments using software such as LabVIEW or other programming languages.

Design and Testing of Instrumentation Systems:

- Design and implement an electronic instrumentation system for a specific application.
- Instrumentation amplifiers and Signal Conditioning Circuits, Differential amplifiers,
- Bridge circuits for sensor interfacing
- Test and troubleshoot the system for proper functionality and performance.

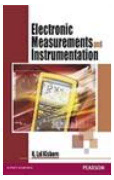
Noise Reduction and Signal Integrity:

- Study different types of noise in electronic circuits and their impact on measurements.
- Design and implement noise reduction techniques to improve signal integrity.

Data Analysis and Visualization:

- Analyze and interpret measurement data using software tools.
- Create visualizations such as graphs and charts to present data effectively.

6.0 TEXT BOOKS



Name: Electronic Measurements and Instrumentation
Author: Lal Kishore
Edition:1st Ed. **(**2009)
Publisher: Pearson
ISBN: 978-8131721995

Name: Electronic Instrumentation
Author: H.S. Kalsi
Edition: 3rd Ed. (2017)
Publisher: McGraw Hill Education
ISBN: 978-0070702066

7.0 REFERENCE BOOKS AND MATERIALS

Name: Measurement and Instrumentation: Theory and Application
Author: Alan S. Morris
Edition: 2nd Ed. (2015)
Publisher: Academic Press Inc
ISBN: 978-0128008843

Name: Principles of Electronic Instrumentation
Author: A.J. Diefenderfer and J.H. Diefenderfer
Edition: 3rd Ed. (1994)
Publisher: Saunders College Pub.
ISBN: 978-0030747090

Name: Modern Electronic Instrumentation and Measurement Techniques
Author: Albert D. Helfrick and William D. Cooper
Edition: 3rd Ed.
Publisher: Prentice-Hall of India
ISBN: 9788120307520

8.0 MAPPING OF CLO TO PO AND PSO

The course outcomes and their mapping with program outcomes are specified in the table below

Course Learning Outcomes	Programme Outcomes (POs)												Programme Specific Outcome (PSOs)					
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CO3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

9.0 ASSESSMENT SCHEME

The evaluation system for this course consists of an 80% weightage on a comprehensive theory examination, which assesses students' understanding of various course topics, and a 20% weightage allocated to internal assessments, including internal examinations, assignments, class participation, and overall engagement in the course throughout the semester.

THEORY:

(A) Internal assessment: (20 marks): Continuous evaluation and internal assessment are implemented to foster and maintain a thorough understanding throughout the learning process. By regularly assessing comprehension through assignments, quizzes, and class participation, educators can address learning gaps promptly and support students in achieving deeper knowledge and proficiency in the subject matter.

(B) End-term examination (80 marks): The end-term examination serves as a culmination of students' learning in the course, assessing their comprehensive understanding and proficiency in various topics in the course. It provides a structured platform for students to demonstrate their knowledge, problem-solving abilities, and application of theoretical concepts, ultimately gauging their readiness to progress. Pattern of End term question paper

Section	Total Questions	Marks for each question	have to attempt	Total Marks
A	5	4	4	20
B	5	10	3	30
C	4	15	2	30

PRACTICUM:

(A) Internal assessment: (20 marks): In the internal assessment of the practicum components, the student's performance, understanding, skills, sincerity, and involvement in laboratory work during the entire semester are evaluated.

(B) End-term examination (80 marks): The ability to apply theoretical knowledge to real-world situations is the fundamental criterion used in the End Term examination. It typically involves students' activity on randomly assigned laboratory works and the Laboratory Report (Notebook) on the performed work in the entire semester. In the End examination, the student must complete randomly assigned tasks and prepare a report on their work, including appropriate conclusions. The mark distribution for the End term examination as follows.

Activity	Marks
Laboratory work in the Examination	40
Laboratory Notebook	20
Presentation/Viva-voce	30

PHY - 001- DE - 42170: ANTENNA AND WAVE PROPAGATION

NCrF Level:	4.5	
Programme:	Four-Year Undergraduate Programme	**Semester:** Eight
Course Category:	Major Course (Departmental Elective)	
Credit (L: T: P)	3: 0: 1	
Credit Hours	Theory: 45 Hours, Practicum: 30 Hours	

1.0 COURSE LEARNING OBJECTIVES

This course aims to provide an in-depth knowledge of antennas of different types and radio wave propagation along with the design, development and practical applications of antennas. The Learning objectives of the course are

- Understand the fundamental principles of antennas and radio wave propagation.
- Learn about various types of antennas and their characteristics.
- Gain proficiency in antenna design and analysis techniques.
- Understand antenna measurement methods.
- Learn about the principles of radio wave propagation and its effects

2.0 COURSE LEARNING OUTCOME

After completing this course, students will be able to,

CO	Outcomes
CO1:	Get a comprehensive understanding of the fundamental principles of antennas, including their performance metrics, radiation mechanisms, and theoretical foundations.
CO2:	Understand to analyse the radiation characteristics, current distributions, field components, and performance metrics of thin linear wire antennas of different kinds.
CO3:	Understand and learn to analyze the design, characteristics, and performance of VHF, UHF, and microwave antennas of different size and shape.
CO4:	understand and analyse the characteristics, design, and performance of microstrip antennas, rectangular patch antennas, reflector antennas, and lens antennas.
CO5:	Learn the characteristics, patterns, and design principles of point sources and arrays and solve related illustrative problems.
CO6:	Learn the concepts and the use of different measurement techniques to evaluate antenna characteristics including directivity, gain, radiation patterns, and impedance.
CO7:	Understand the basic principles of electromagnetic wave propagation, including reflection, refraction, diffraction, and scattering.
CO8:	Apply theoretical knowledge to practical scenarios in antenna and wave propagation, such as designing as well as optimizing antennas for wireless communications
CO9:	Understand the regulatory environment related to antennas and wave propagation, including spectrum management and compliance with communication standards.
CO10:	Acquire practical experience with diverse antenna types, analyze their characteristics, and compose a concise report using scientific methods.

3.0 SKILLS TO BE LEARNED

- To Design and construction of antenna of some specific types
- To use measurement techniques to evaluate antenna characteristics
- To apply simulation tools for modelling antenna performance and optimizing designs.
- To Integrate antennas into communication systems and apply them effectively in practically.

4.0 DETAILED CONTENTS OF THE COURSE: THEORY

Credit: 3 **Classroom Teaching: 45 Horus**

MODULE 1

Antenna Basics: Beam Efficiency, Directivity-Gain-Resolution, Antenna Apertures, Illustrative Problems. Fields from Oscillating Dipole, Field Zones, Front - to-back Ratio, Antenna Theorems, Radiation, Retarded Potentials – Helmholtz Theorem. **[5 hours]**

Thin Linear Wire Antennas – Radiation from Small Electric Dipole, Quarter Wave Monopole and Half Wave Dipole – Current Distributions, Field Components, Radiated Power, Radiation Resistance, Beam Width, Directivity, Effective Area, Effective Height, Natural Current Distributions, Far Fields and Patterns of Thin Linear Centre-fed Antennas of Different Lengths, Illustrative Problems. **[5 hours]**

VHF, UHF and Microwave Antennas - I : Arrays with Parasitic Elements, Yagi-Uda Array, Folded Dipoles and their Characteristics, Helical Antennas – Helical Geometry, Helix Modes, Practical Design Considerations for Monofilar Helical Antenna in Axial and Normal Modes, Horn Antennas – Types, Optimum Horns, Design Considerations of Pyramidal Horns, Illustrative Problems. **[5 hours]**

MODULE 2

VHF, UHF and Microwave Antennas - II: Microstrip Antennas – Introduction, Features, Advantages and Limitations, Rectangular Patch Antennas – Geometry and Parameters, Characteristics of Microstrip Antennas. Impact of Different Parameters on Characteristics, Reflector Antennas – Introduction, Flar Sheet and Corner Reflectors, Paraboloidal Reflectors – Geometry, Pattern Characteristics, Feed Methods, Reflector Types – Related Features, Illustrative Problems. Lens Antennas – Introduction, Geometry of Non-metallic Dielectric Lenses, Zoning, Applications. **[7 hours]**

Antenna Arrays: Point Sources – Definition, Patterns, arrays of 2 Isotropic Sources - Different Cases, Principle of Pattern Multiplication, Uniform Linear Arrays – Broadside Arrays, Endfire Arrays, EFA with Increased Directivity, Derivation of their Characteristics and Comparison, BSAs with Non-uniform Amplitude Distributions – General Considerations and Binomial Arrays, Illustrative Problems. **[5 hours]**

Antenna Measurements: Introduction, Concepts - Reciprocity, Near and Far Fields, Coordinate System Patterns to be Measured, Pattern Measurement Arrangement, Directivity Measurement, Gain Measurements (by Comparison, Absolute and 3- Antenna Methods) **[3 hours]**

MODULE 3

Wave Propagation: Introduction, Definitions, Categorizations and General Classifications, Different Modes of Wave Propagation, Ray/Mode Concepts, Ground Wave Propagation (Qualitative Treatment) – Introduction, Plane Earth Reflections, Space and Surface Waves, Wave Tilt, Curved Earth Reflections. Space Wave Propagation – Introduction, Field Strength Variation with Distance and Height, Effect of Earth‘s Curvature, Absorption, Super Refraction, M-Curves and Duct Propagation, Scattering Phenomena, Tropospheric Propagation. Sky Wave Propagation – Introduction, Structure of Ionosphere, Refraction and Reflection of Sky Waves by Ionosphere, Ray Path, Critical Frequency, MUF, LUF, OF, Virtual Height and Skip Distance, Relation between MUF and Skip Distance, Multihop Propagation. **[15 hours]**

5.0 DETAILED CONTENTS OF THE COURSE: PRACTICUM

Credit: 2 **Laboratory Work: 60 Hours**

In the practicum component of the course, students will learn the physics behind the antenna and wave propagation through a series of laboratory experiments. They have to go through hands-on experience with different instruments used to study antenna characteristics and parameters.

In the laboratory classes, students are required to conduct experiments from the provided list, meticulously following the suggested procedures and protocols outlined for each. Subsequently, they must compile comprehensive reports for every experiment, adhering to scientific standards and conventions. These reports should encompass a detailed description of the experimental setup and methodology employed, including any modifications made during the experiment. Furthermore, students are expected to record and analyze their experimental data systematically, drawing upon relevant theoretical concepts and principles to interpret their findings accurately. Additionally, the reports should include a thorough discussion of the results obtained, highlighting any observed trends, anomalies, or correlations, and offering insightful explanations or hypotheses where applicable. Moreover, students must demonstrate proficiency in presenting their results graphically, utilizing tables, figures, and diagrams to enhance clarity and facilitate comprehension. Finally, each report should conclude with a succinct summary of the key findings and conclusions drawn from the experiment, along with any recommendations for further investigation or improvement.

The teacher has the flexibility to introduce a wide range of laboratory experiments that directly correlate with and reinforce the theoretical concepts covered in the course curriculum. These experiments serve as practical applications of the theoretical principles discussed in lectures.

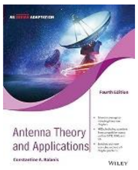
Suggested List of Acativity/Experiments:

1. Dipole Antenna Design and Measurement
    - Design and construct a dipole antenna
    - Measure radiation patterns, impedance, and gain.
2. Analyze the results and compare them with theoretical predictions
    - Loop Antenna Design and Analysis
    - Construct a small loop antenna.
3. Measure the radiation pattern and impedance –
    - Compare the performance with theoretical models
    - Patch Antenna Design and Fabrication
4. Design and fabricate a microstrip patch antenna –
    - Measure radiation patterns, gain, and impedance
    - Test different substrates and patch shapes for performance variations.
5. Yagi-Uda Antenna Design and Testing-
    - Construct a Yagi-Uda antenna
    - Measure radiation patterns, gain, and front-to-back ratio
    - Explore the impact of element spacing and length on performance.
6. Antenna Arrays –
    - Construct and test linear and planar antenna arrays
    - Measure radiation patterns, beamwidth, and gain
    - Experiment with phase and amplitude control for beam steering
7. Phased Array Antenna Experiment –
    - Explore the design and operation of a phased array antenna

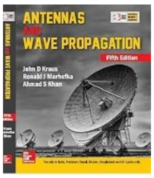
- Experiment with beamforming and beam steering
- Measure the radiation patterns and performance

8. Impedance Matching and Tuning –
    - Explore different methods of impedance matching
    - Design and test matching networks for different types of antennas
    - Experiment with variable tuning elements.
9. Antenna Measurements –
    - Learn to use of network analyzers and , spectrum analyzers.
    - Measure return loss, VSWR, and other performance parameters
    - Calibrate measurement equipment and interpret results.
10. Simulation and Modelling –
    - Use simulation software to design and model antennas
    - Compare simulated results with experimental measurements
    - Optimize designs based on simulation outcomes.

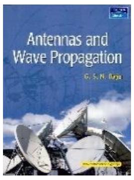
TEXT BOOKS



Name: Antenna Theory and Applications
Author: Constantine A. Balanis
Edition: Wiley
Publisher: 4th Ed
ISBN: 978-9354248474

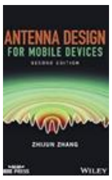


Name: Antennas and Wave Propagation
Author: John D. Kraus, Ronald J. Marhefka, Ahmad S. Khan
Edition: 5th Ed.
Publisher: McGraw Hill Education
ISBN: 978-9352606184

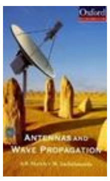


Name: Antenna and Wave Propagation
Author: G. S. N. Raju
Edition: 1st Ed.
Publisher: Pearson Education India
ISBN: 978-8131701843

REFERENCE BOOKS AND MATERIALS



Name: Antenna Design for Mobile Devices
Author: Zhijun Zhang
Edition: 2nd Ed. (2017)
Publisher: Wiley
ISBN: 978-1119132325



Name: Antenna and Wave Propagation
Author: A.R. Harish and M. Sachidananda
Edition: 2007
Publisher: Oxford University Press
ISBN: 978-0195686661

6.0 MAPPING OF CLO TO PO AND PSO

The course outcomes and their mapping with program outcomes are specified in the table below

Course Learning Outcomes	Programme Outcomes (POs)												Programme Specific Outcome (PSOs)					
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6
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CO2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

9.0 ASSESSMENT SCHEME

The evaluation system for this course consists of an 80% weightage on a comprehensive theory examination, which assesses students' understanding of various course topics, and a 20% weightage allocated to internal assessments, including internal examinations, assignments, class participation, and overall engagement in the course throughout the semester.

THEORY:

(A) Internal assessment: (20 marks): Continuous evaluation and internal assessment are implemented to foster and maintain a thorough understanding throughout the learning process. By regularly assessing comprehension through assignments, quizzes, and class participation, educators can address learning gaps promptly and support students in achieving deeper knowledge and proficiency in the subject matter.

(B) End-term examination (80 marks): The end-term examination serves as a culmination of students' learning in the course, assessing their comprehensive understanding and proficiency in various topics in the course. It provides a structured platform for students to demonstrate their knowledge, problem-solving abilities, and application of theoretical concepts, ultimately gauging their readiness to progress. Pattern of End term question paper

Section	Total Questions	Marks for each question	have to attempt	Total Marks
A	5	4	4	20
B	5	10	3	30
C	4	15	2	30

PRACTICUM:

(A) Internal assessment: (20 marks): In the internal assessment of the practicum components, the student's performance, understanding, skills, sincerity, and involvement in laboratory work during the entire semester are evaluated.

(B) End-term examination (80 marks): The ability to apply theoretical knowledge to real-world situations is the fundamental criterion used in the End Term examination. It typically involves students' activity on randomly assigned laboratory works and the Laboratory Report (Notebook) on the performed work in the entire semester. In the End examination, the student must complete randomly assigned tasks and prepare a report on their work, including appropriate conclusions. The mark distribution for the End term examination as follows.

Activity	**Marks**
Laboratory work in the Examination	40
Laboratory Notebook	20
Presentation/Viva-voce	20

PHY - 001- DE - 42180: INTRODUCTION TO ARDUINO

NCrF Level:	6.0	
Programme:	Four-Year Undergraduate Programme	**Semester:** Eight
Course Category:	Major Course (Departmental Elective)	
Credit (L: T: P)	2: 0: 2	
Credit Hours	Theory: 30 Hours, Practicum: 60 Hours	

1.0 COURSE LEARNING OBJECTIVES

The aim of the course is to provide a comprehensive understanding about Arduino hardware and software and sensor interfacing. Through a series of exercises students will gain proficiency in building Arduino-based systems required for different physics experiments. The learning objectives of this course are:

(a) Understand the fundamentals of Arduino and the Arduino development environment.
(b) Learn programming concepts such as variables, control structures, functions, and libraries.
(c) Gain proficiency in sensor interfacing and I/O control using Arduino.
(d) Explore basic electronics concepts and circuit design through Arduino projects.
(e) Apply acquired knowledge to design and implement creative Arduino projects.

2.0 COURSE LEARNING OUTCOME

After completing this course, students will be able to,

CO	Outcomes
CO1:	Demonstrate a comprehensive understanding of Arduino hardware components, programming environment, and basic syntax.
CO2:	Design and construct electronic circuits using Arduino boards, breadboards, and various electronic components.
CO3:	Learn to create, upload, and troubleshoot Arduino sketches for various actuators, control sensors, and other peripherals.
CO4:	Apply programming concepts such as variables, conditionals, loops, functions, and serial communication to Arduino projects.
CO5:	Troubleshoot and debug Arduino programs and electronic circuits to identify and resolve common issues.
CO6:	Implement functional Arduino-based projects that demonstrate creativity and innovation in solving real-world problems.
CO7:	Learn to document project designs, including schematics, code explanations, and project outcomes, and effectively present their projects to peers and instructors.

3.0 SKILLS TO BE LEARNED

- To Build and test circuits using breadboards and connect components to the Arduino.
- Arduino programming language to interface with various electronic components
- To design and develop electronic measuring experiments for the physics laboratory
- To use of Python programming language for the development of Arduino-based devices.

4.0 DETAILED CONTENTS OF THE COURSE: THEORY

Credit: 3 **Classroom Teaching: 45 Horus**

MODULE 1

Introduction to Arduino: Overview of Arduino microcontrollers and their applications, Introduction to the Arduino Development Environment (IDE), Setting up the Arduino IDE and connecting Arduino boards

Arduino Programming Basics: Introduction to Arduino programming language (based on C/C++), Variables, data types, and operators, Control structures: if-else statements, loops (for, while), Functions and basic debugging techniques

Input/Output (I/O) Control: Digital input/output (GPIO) with Arduino, Analog input using analog-to-digital conversion (ADC), PWM (Pulse Width Modulation) for analog output, Controlling external devices: LEDs, buttons, buzzers

Sensor Interfacing: Introduction to sensors and transducers, Interfacing digital and analog sensors with Arduino, Reading sensor data and processing sensor inputs, Calibration and troubleshooting of sensor connections

MODULE 2

Communication Interfaces: Serial communication with Arduino: UART, SPI, I^{2}C, Using Arduino as a USB HID (Human Interface Device), Introduction to wireless communication with Arduino (Wi-Fi, Bluetooth),

Display and User Interface: Interfacing LCDs (Liquid Crystal Displays) with Arduino, creating interactive user interfaces with buttons and displays, Introduction to graphical displays (OLED, TFT) and libraries, Real-time operating systems (RTOS) and multitasking with Arduino

Arduino with Python: Interfacing Arduino with Python, communicating with Arduino using Python (sending and receiving data), Arduino-Python communication (e.g., PySerial). Reading and display of sensor data using python, control actuators (motors, servos, relays) using python, Data logging and visualization though Arduino using python.

5.0 DETAILED CONTENTS OF THE COURSE: PRACTICUM

Credit: 2 **Laboratory Work: 60 Hours**

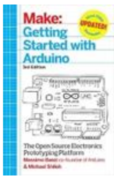
In the practical component of the course, students will undergo hands-on experience with diverse types of Arduino microcontroller boards. Through a series of exercises, students will learn to use of Arduino in a Physics Laboratory. In the laboratory, students have to design and build Arduino-based circuits to measure various physical parameters.

Suggested exercises include:

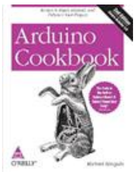
1. Setting up the development environment for Arduino
2. Writing simple sketches to control LEDs, buzzers, and other components – using of variable, loop and function
3. Interfacing Arduino with various sensors (e.g., temperature, light, motion) - Collecting and analyzing sensor data.
4. Controlling actuators such as motors, servos, and relays - Implementing PWM for precise control.
5. Establishing serial communication between Arduino and a computer - Sending and receiving data using serial protocols.
6. Exploring wireless communication options (e.g., Bluetooth, Wi-Fi) - Interfacing with wireless modules.
7. Working with displays (e.g., LCD, OLED) and user interfaces.
8. Storing and logging data using SD cards and other storage options - Analysing and visualizing data.

9. Design and implement projects that integrate multiple components
10. Experient combining Arduino and Python
11. Project with
    - Home automation systems
    - Environmental monitoring with sensors
    - Robotics and motor control
    - Wearable electronics and interactive installations

6.0 TEXT BOOKS

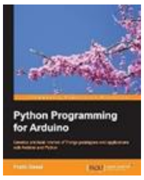


Name: Getting Started with Arduino: The Open-Source Electronics Prototyping Platform
Author: Massimo Banzi
Edition: 3rd Ed.(2015)
Publisher: Make Community, LLC
ISBN: 978-1449363338

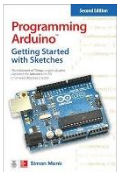


Name: Arduino Cookbook
Author: Michael Margolis
Edition: 2nd Ed. (2012)
Publisher: O'Reilly
ISBN: 978-9350236123

7.0 REFERENCE BOOKS AND MATERIALS

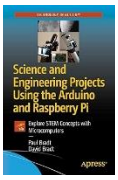


Name: Python Programming for Arduino: Advanced Guide to Control Arduino with Python Language
Author: Pratik Desai
Edition: 2015
Publisher: Packt Pub Ltd
ISBN: 978-1783285938

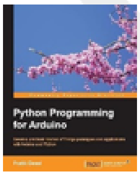


Name: Programming Arduino: Getting Started with Sketches
Author: Simon Monk
Edition: 2nd Ed.
Publisher: McGraw Hill
ISBN: 978-1259641633

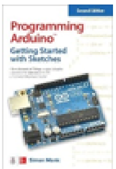
Name: Exploring Arduino: Tools and Techniques for Engineering
Author: Jeremy Blum
Edition: 2013
Publisher: Wiley
ISBN: 978-1118549360



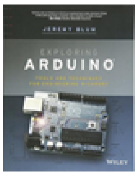
Name: Science and Engineering Projects Using the Arduino and Raspberry Pi
Author: Paul Bradt, David Bradt
Edition: 1st Ed. (2020)
Publisher: Apress
ISBN: 9781484258118



Name: Python Programming for Arduino: Advanced Guide to Control Arduino with Python Lang
Author: Pratik Desai
Edition: 2015
Publisher: Packt Pub Ltd
ISBN: 978-1783285938



Name: Programming Arduino: Getting Started with Sketches
Author: Simon Monk
Edition: 2nd Ed.
Publisher: McGraw Hill
ISBN: 978-1259641633



Name: Exploring Arduino: Tools and Techniques for Engineering
Author: Jeremy Blum
Edition: 2013
Publisher: Wiley
ISBN: 978-1118549360

6.0 MAPPING OF CLO TO PO AND PSO

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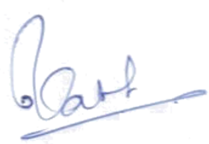
CO3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

9.0 ASSESSMENT SCHEME

The evaluation system for this course consists of an 80% weightage on a comprehensive theory examination, which assesses students' understanding of various course topics, and a 20% weightage allocated to internal assessments, including internal examinations, assignments, class participation, and overall engagement in the course throughout the semester.

THEORY:



(A) Internal assessment: (20 marks): Continuous evaluation and internal assessment are implemented to foster and maintain a thorough understanding throughout the learning process. By regularly assessing comprehension through assignments, quizzes, and class participation, educators can address learning gaps promptly and support students in achieving deeper knowledge and proficiency in the subject matter.

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PRACTICUM:

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(B) End-term examination (80 marks): The ability to apply theoretical knowledge to real-world situations is the fundamental criterion used in the End Term examination. It typically involves students' activity on randomly assigned laboratory works and the Laboratory Report (Notebook) on the performed work in the entire semester. In the End examination, the student must complete randomly assigned tasks and prepare a report on their work, including appropriate conclusions. The mark distribution for the End term examination as follows.

Activity	Marks
Laboratory work in the Examination	40
Laboratory Notebook	20
Presentation/Viva-voce	20

PHY - 001- DE - 42190: INTRODUCTION TO RASPBERRY PI

NCrF Level:	4.5	
Programme:	Four-Year Undergraduate Programme	**Semester:** Eight
Course Category:	Major Course (Departmental Elective)	
Credit (L: T: P)	3: 0: 2	
Credit Hours	Theory: 30 Hours, Practicum: 60 Hours	

1.0 COURSE LEARNING OBJECTIVES

This course provides an introduction to programming with Raspberry Pi and allows to explores its applications in various projects. Students will learn the basics of Raspberry Pi hardware, Linux operating system, Python programming language, and interfacing with peripherals though practical exercises. The Learning Objectives of this course are

(a) Understand the fundamentals of Raspberry Pi hardware and software.
(b) Learn programming concepts using Python programming language.
(c) Gain proficiency in interfacing sensors, actuators, and other peripherals with Raspberry Pi.
(d) Explore practical applications of Raspberry Pi in different domains.
(e) Apply acquired knowledge to design and implement creative Raspberry Pi projects

2.0 COURSE LEARNING OUTCOME

After completing this course, students will be able to,

CO	Outcomes
CO1:	Understand the origin, development, and key milestones of the Raspberry Pi, from its inception to its current models and their role in laboratory experiment and everyday life.
CO2:	Assemble the Raspberry Pi with necessary peripherals such as power supply, display, keyboard, mouse, storage and other peripherals.
CO3:	Able to navigate Raspberry Pi OS, perform command-line operations, manage software packages effectively and to write and run scripts, utilizing various libraries and packages.
CO4:	Develop Python scripts for Raspberry Pi, integrating GPIO control, sensor interaction, and communication protocols, enabling them to build versatile and functional projects.
CO5:	Understanding and programming GPIO pins, handling managing inputs to connect sensors and actuators, as well as to handling ADC and PWM.
CO6:	Able to implement serial communication protocols, manage network communication via Ethernet, Wi-Fi, Bluetooth, MQTT for practical applications.
CO7:	Learn to write detailed and scientifically rigorous laboratory reports on Raspberry Pi based projects, including documentation of objectives, methodologies, data analysis and conclusions

3.0 SKILLS TO BE LEARNED

- Assemble and set up a Raspberry Pi board and connecting peripherals as per the requirements.
- proficiency in programming using Python to develop Raspberry Pi based experiments and project
- to interface with external hardware through GPIO pins of Raspberry Pi for physical computing

4.0 DETAILED CONTENTS OF THE COURSE: THEORY

Credit: 3 **Classroom Teaching: 45 Horus**

MODULE 1

Introduction to Raspberry Pi: Overview of Raspberry Pi: history, versions, features, setting up Raspberry Pi hardware and peripherals, different models of raspberry pi, Applications of Raspberry Pi in various fields, Importance of Raspberry pi in Physics Laboratory, Setting up your Raspberry Pi: Hardware components, peripherals, and connections. **[5 hours]**

Raspberry Pi software and programming: Raspberry Pi OS and its features, Linux Operating Systems for Raspberry Pi (e.g., Raspbian), Command-line basics and software package management, booting up, Using the Raspberry Pi desktop environment, File management on Raspberry Pi. Introduction to the Linux terminal and basic commands, Network configuration and internet connectivity **[5 hours]**

Raspberry Pi and Python: Overview of Python on Raspberry Pi, setting up a Python development environment on Raspberry Pi, Writing and executing Python scripts. Basic Python syntax, data types, variables, and operators, Control flow statements (if-else, loops) and functions, Using Python libraries for Raspberry Pi**. [5 hours]**

MODULE 2

Interfacing with GIPO: Understanding General Purpose Input/Output (GPIO) pins and their capabilities, GPIO programming with Python - Controlling LEDs, buttons and other digital peripherals. **[2 hours]**

Analog Inputs and Outputs: Introduction to analog-to-digital conversion (ADC) and pulse-width modulation (PWM), Interfacing analog sensors and actuators with Raspberry Pi, reading analog sensor data and controlling analog outputs, Interfacing with hardware peripherals such as camera, display etc **[4 hours]**

Working with Sensors and Actuators: Introduction to common sensors: temperature, humidity, motion, light, etc., Interfacing sensors with Raspberry Pi and reading sensor data, Controlling actuators such as motors, servos, and relays **[4 hours]**

Communication Interfaces: Serial communication with Raspberry Pi: UART, SPI, I2C, Using Raspberry Pi for network communication: Ethernet, Wi-Fi, Introduction to wireless communication with Raspberry Pi (Bluetooth, MQTT) **[5 hours]**

5.0 DETAILED CONTENTS OF THE COURSE: PRACTICUM

Credit: 2 **Laboratory Work: 60 Hours**

In the practical component of the course, students will gain hands-on experience with various Raspberry Pi models and programming them in Python. Through a series of practical exercises, students will explore the application of Raspberry Pi in physics laboratories and real-world scenarios. Additionally, students will design and construct interfaces between Raspberry Pi and electronic circuits for diverse applications in the laboratory. The suggested list of experiments includes

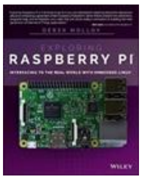
1. Write a Python script to make an LED connected to GPIO pin blink at a specific interval.
2. Experiment with different blink patterns (e.g., Morse code, fading in and out).
3. Create a program to detect when a button connected to a GPIO pin is pressed and released.
4. Use this input to control an LED or trigger other actions on the Raspberry Pi.
5. Interface a DHT11 or DHT22 sensor with the Raspberry Pi to measure temperature and humidity.
6. Display real-time sensor readings on an LCD display or log them to a file.
7. Use the Raspberry Pi Camera Module to capture images or video when motion is detected.
8. Implement motion detection algorithms using Python and OpenCV library.
9. Connect Raspberry Pi to the internet using Wi-Fi or Ethernet.
10. Implement a simple IoT application like remote monitoring of sensor data using MQTT protocol or web server.
11. Use a buzzer or speaker connected to GPIO pins to generate tones or play music files.

12. Create a program to play specific melodies or respond to external triggers (like button presses).
13. Build a simple robot using DC motors and motor drivers controlled by Raspberry Pi GPIO.
14. Write a program to navigate the robot, avoid obstacles, or follow lines using sensors.
15. Collect data from sensors (e.g., temperature, light intensity) over time.
16. Store data in a database or CSV file and create graphs or charts for visualization using Python libraries like matplotlib.
17. Implement voice recognition using a USB microphone or the Raspberry Pi's built-in microphone.
18. Control LEDs, motors, or other devices based on voice commands using libraries like Speech Recognition and PyAudio.
19. Integrate multiple sensors (temperature, motion, light) and actuators (LEDs, motors, relays) to create a home automation system.
20. Control devices remotely through a web interface or smartphone app using Flask or MQTT.

In addition to this student have to develop a **Raspberry Pi based Physics experiments**.

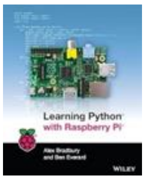
TEXT BOOKS

Name: Raspberry Pi For Dummies
Author: Sean McManus, Mike Cook
Edition: 4^{th} Ed. (2021)
Publisher:
ISBN: 978-1119796824

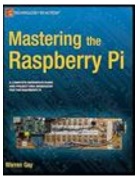


Name: Exploring Raspberry Pi: Interfacing to the Real World with Embedded Linux
Author: Derek Molloy
Edition: 1^{st} Ed. (2016)
Publisher: Wiley
ISBN: 978-1119188681

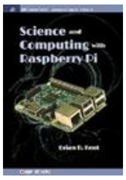
REFERENCE BOOKS AND MATERIALS



Name: Learning Python with Raspberry Pi
Author: Alex Bradbury and Ben Everard
Edition: 1^{st} Ed. (2014)
Publisher: John Wiley & Sons
ISBN: 978-1118717059



Name: Mastering the Raspberry Pi
Author: Warren Gay
Edition: 1^{st} Ed. (2014)
Publisher: Apress
ISBN: 978-1484201824



Name: Science and Computing with Raspberry Pi
Author: Brian R Kent
Edition: 2018
Publisher: Morgan & Claypool Publishers
ISBN: 9781681749969

6.0 MAPPING OF CLO TO PO AND PSO

The course outcomes and their mapping with program outcomes are specified in the table below

Course Learning Outcomes	Programme Outcomes (POs)												Programme Specific Outcome (PSOs)					
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6
CO1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

9.0 ASSESSMENT SCHEME

The evaluation system for this course consists of an 80% weightage on a comprehensive theory examination, which assesses students' understanding of various course topics, and a 20% weightage allocated to internal assessments, including internal examinations, assignments, class participation, and overall engagement in the course throughout the semester.

THEORY:

(A) Internal assessment: (20 marks): Continuous evaluation and internal assessment are implemented to foster and maintain a thorough understanding throughout the learning process. By regularly assessing comprehension through assignments, quizzes, and class participation, educators can address learning gaps promptly and support students in achieving deeper knowledge and proficiency in the subject matter.

(B) End-term examination (80 marks): The end-term examination serves as a culmination of students' learning in the course, assessing their comprehensive understanding and proficiency in various topics in the course. It provides a structured platform for students to demonstrate their knowledge, problem-solving abilities, and application of theoretical concepts, ultimately gauging their readiness to progress. Pattern of End term question paper

Section	Total Questions	Marks for each question	have to attempt	Total Marks
A	5	4	4	20
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C	4	15	2	30

PRACTICUM:

(A) Internal assessment: (20 marks): In the internal assessment of the practicum components, the student's performance, understanding, skills, sincerity, and involvement in laboratory work during the entire semester are evaluated.

(B) End-term examination (80 marks): The ability to apply theoretical knowledge to real-world situations is the fundamental criterion used in the End Term examination. It typically involves students' activity on randomly assigned laboratory works and the Laboratory Report (Notebook) on the performed work in the entire semester. In the End examination, the student must complete randomly assigned tasks and prepare a report on their work, including appropriate conclusions. The mark distribution for the End term examination as follows.

Activity	Marks
Laboratory work in the Examination	40
Laboratory Notebook	20
Presentation/Viva-voce	20

PHY - 001- DE - 42200: TRANSPORT PROPERTIES OF MATERIALS

NCrF Level:	6.0	
Programme:	Four Year Undergraduate Programme	**Semester:** Eight
Course Category:	Major	
Credit (L: T: P)	2: 0: 2	
Credit Hours	Theory: 30 Hours, Practical: 60 Hours	

1.0 COURSE LEARNING OBJECTIVES

This course reviews the basic concepts of electrical properties of solids. It begins with explaining the ideas on various parameters related to conductor and insulators. The course also provides an in depth understanding of electrical properties of semiconductor and their junction metals.

2.0 COURSE LEARNING OUTCOME

After completing this course, students will be able to,

CO	Outcomes
CO1:	Understand the basic electrical properties of different types of solids.
CO2:	Explain the variation of electrical properties in terms of the structural organization
CO3:	Understand the various factors that influence the electrical properties.
CO4:	Knowledge on the role of dielectrics and insulators in electronical applications.
CO5:	Understanding the electrical transport at material junction.
CO6:	Explain several phenomena we can observe in everyday life that can be explained as electrical transport.
CO7:	Use of spectrometer and lasers, and necessary precautions during the experiments
CO8:	Understand the efficacy of emerging materials in improved transport parameters.
CO9:	Sessions on the review of experimental data analysis, sources of error and their estimation in detail, writing of scientific laboratory reports including proper reporting of errors.
CO10:	Linearization of data and the use of slope and intercept to determine unknown quantities.

3.0 SKILLS TO BE LEARNED

- Training in calculus will prepare the student to analyze electrical properties of materials.
- He / she shall develop an understanding of how to formulate the intrinsic property of the solid to the electrical output.

4.0 DETAILED CONTENTS OF THE COURSE: THEORY

Credit: 3 **Classroom Teaching: 45 Horus**

MODULE 1

Introduction to Electrical Properties of Materials: Review of Conductors and Their Electrical Properties, temperature dependence of resistivity, skin effect, General Properties of Conductor- Electrical conductivity, resistivity, and resistance. Ohm's law and relaxation time of electrons, collision time and mean free path, electron scattering and resistivity of metals, Free electron theory and electrical conduction in metals. Temperature dependence of resistivity in conductors. **[7 hours]**

Electrical properties of Insulators and Dielectrics: Characteristics of insulators and dielectric materials, Dielectric constant, loss tangent, and breakdown voltage, Polarization mechanisms in dielectrics, Applications of insulators and dielectrics in electronics. **[3 hours]**

Semiconductors and Their Electrical Properties: Carrier transport in semiconductors, drift, conductivity and mobility, variation of mobility with temperature and doping, Diffusion, Einstein relations, Poisson equations, Continuity equations, Current flow equations, Diffusion length, Gradient of the quasi-Fermi level. Energy bands in semiconductors: conduction and valence bands, energy bands Intrinsic and extrinsic semiconductors, Hall Effect. **[5 hours]**

MODULE 2

Electrical Properties at Material Junctions: Electrical characteristics at p-n junctions, Schottky junctions, and heterojunctions, Contact potential, Electrical Field, Potential and Charge distribution at the junction, Biasing and Energy band diagrams, Ideal diode equation. Metal Semiconductor contacts, Electron affinity and work function, Ohmic and Rectifying Contacts, electrical transport in BJT - characteristics, Transistor action, Base width modulation, UJT. **[8 hours]**

Electrical properties of Emerging Materials: Application of low dimensional materials: Quantum dots /Nanomaterials/ 2D materials/ Perovskite materials, application of nanomaterials in MOSFETs for improved performance. Carbon nanotube and graphene MOSFETs., Impact of nanomaterials on threshold voltage, mobility, and on-off current ratio, Nanomaterial-based MOS memories: non-volatile memories and resistive random-access memory (RRAM). 2D materials in MOS technology. **[7 hours]**

5.0 DETAILED CONTENTS OF THE COURSE: PRACTICUM

Credit: 2 **Laboratory Work: 60 Hours**

In this course, the students will learn the operation of test equipment and measurement techniques. Hands on understanding of the experimental set-up will be gained by the students. They come across the diverse factors that influence the transport property in materials. The students will be able to efficiently troubleshoot and fix incorrect settings and can reliably measure data with limited errors. It will also help them to perform routine calibrations of the equipment.

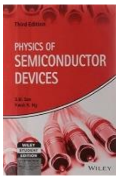
Students will be able to conduct experiments and collect and record data. In particular, the students will be able to use techniques to minimize errors and eliminate artefacts, to troubleshoot hardware to collect sufficient data (both in terms of quantity and quality) to achieve lab goals, to demonstrate comprehensive and well organized records, and to establish conclusive robust results.

The teacher has the flexibility to introduce a wide range of laboratory experiments that directly correlate with and reinforce the theoretical concepts covered in the course curriculum. These experiments serve as practical applications of the theoretical principles discussed in lectures.

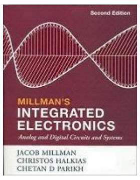
1. To study the influence of temperature on electrical conductivities of metals and semiconductors
2. To study the dielectric behavior of material at different frequency signal.
3. To study the temperature dependence of dielectric property of materials under different frequencies
4. To study the frequency dependent dielectric loss for a given material and understanding the factors involved in the process of dielectric loss.
5. To study the variation of dielectric behavior of composite material at different filler content.
6. To study temperature electron transport in intrinsic and extrinsic semiconductors.
7. To study the electron transport in the material using van der Pauw method.

8. Measurement of resistivity and determination of band gap of a compound semiconductor using the Four Probe method.
9. To study the capacitance at material junctions and its dependency on temperature
10. To study the voltage dependent transport mechanisms of a pn-junction diode
11. Determination of Hall mobility of carriers in semiconductors.
12. Determination of Hall mobility of carriers in Metals.
13. To study the transport characteristic of solids having color centers.
14. To study the variation of temperature on a metal-semiconductor junction.
15. To study the variation of temperature on a metal-insulator-semiconductor junction.
16. To study the variation of temperature on the characteristics of a BJT.
17. To study the variation of temperature on the characteristics of an UJT.
18. To study
    a. The optical characteristics of semiconductor laser
    b. The spectral curve of semiconductor laser
    c. basic parameters of semiconductor laser such as divergence angle and degree of polarization

6.0 TEXT BOOKS

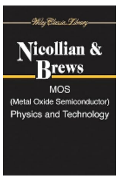


Name: Physics of Semiconductor Devices
Author: S. M. Sze, Kwok K. Ng
Edition: 2010
Publisher: Wiley
ISBN: 978-8126517022

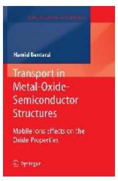


Name: . Integrated Electronics
Author: Jacob Millman, Christos Halkias and Chetan Parikh
Edition: 2011
Publisher: McGraw Education .
ISBN: Integrated Electronics

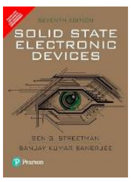
7.0 REFERENCE BOOKS AND MATERIALS



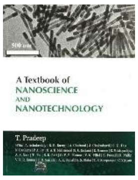
Name: MOS (Metal Oxide Semiconductor) Physics and Technology
Author: E. H. Nicollian, J. R. Brews
Edition: 1982
Publisher: Wiley
ISBN: 978-0471430797



Name: Transport in Metal-Oxide-Semiconductor Structures
Author: Hamid Bentarzi
Edition: 2011
Publisher: Springer.
ISBN: **978-3642266881**



Name: Solid State Electronics Devices,
Author: B.G. Streetman, S. K. Banerjee
Edition: 2016
Publisher: Pearson
ISBN: 978-0131497269



Name: A Textbook of Nanoscience and Nanotechnology
Author: T. Pradeep
Edition: 2017
Publisher: McGraw Hill
ISBN: 978-1259007323

8.0 MAPPING OF CLO TO PO AND PSO

The course outcomes and their mapping with program outcomes are specified in the table below

Course Learning Outcomes	Programme Outcomes (POs)												Programme Specific Outcome (PSOs)					
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CO3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

9.0 ASSESSMENT SCHEME

The evaluation system for this course consists of an 80% weightage on a comprehensive theory examination, which assesses students' understanding of various course topics, and a 20% weightage allocated to internal assessments, including internal examinations, assignments, class participation, and overall engagement in the course throughout the semester.

THEORY:

(A) Internal assessment: (20 marks): Continuous evaluation and internal assessment are implemented to foster and maintain a thorough understanding throughout the learning process. By regularly assessing comprehension through assignments, quizzes, and class participation, educators can address learning gaps promptly and support students in achieving deeper knowledge and proficiency in the subject matter.

(B) End-term examination (80 marks): The end-term examination serves as a culmination of students' learning in the course, assessing their comprehensive understanding and proficiency in various topics in the course. It provides a structured platform for students to demonstrate their knowledge, problem-solving abilities, and application of theoretical concepts, ultimately gauging their readiness to progress. Pattern of End term question paper

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PRACTICUM:

(A) Internal assessment: (20 marks): In the internal assessment of the practicum components, the student's performance, understanding, skills, sincerity, and involvement in laboratory work during the entire semester are evaluated.

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Activity	Marks
Laboratory work in the Examination	40
Laboratory Notebook	20
Presentation/Viva-voce	20

PHY - 001- DE - 42210: SEMICONDUCTOR TECHNOLOGY AND DEVICES

NCrF Level:	6.0	
Programme:	Four Year Undergraduate Programme	**Semester:** Eight
Course Category:	Major Couse (Departmental Elective)	
Credit (L: T: P)	2: 0: 2	
Credit Hours	Theory: 30 Hours, Practicum: 60 Hours	

1.0 COURSE LEARNING OBJECTIVES

This course reviews the semiconductor technology and device application strategies. It begins with explaining ideas of semiconductor fabrication and packaging. The course also provides an in depth understanding of metal oxide semiconductor (MOS) technology and emphasizes on the transport property in MOS. It also highlights the integrated device fabrication strategies

2.0 COURSE LEARNING OUTCOME

After completing this course, students will be able to,

CO	Outcomes
CO1:	Understand the semiconductor fabrication technology.
CO2:	Understanding the semiconductor processing technology.
CO3:	Knowledge on the traditional methods for packaging semiconductors.
CO4:	Idea about the advanced packaging technologies.
CO5:	Apply the measurement techniques for evaluation of the transport parameters.
CO6:	Understanding basic features of metal oxide semiconductors (MOS), MOS capacitors and MOSFETs.
CO7:	Optimization of MOS/MOSFETs through the knowledge of scaling and channel effects.
CO8:	Knowledge on the integration of semiconductor chips for device application.
CO9:	Hand on experience on transport properties of MOS devices along with theoretical simulations
CO10:	Sessions on the review of experimental data analysis, and writing of scientific laboratory reports including proper reporting of errors.

3.0 SKILLS TO BE LEARNED

- Training on determination of transport parameters in solids.
- He / she shall develop an understanding of how to the application of MOS in modern devices.

4.0 DETAILED CONTENTS OF THE COURSE: THEORY

Credit: 3 **Classroom Teaching: 30 Horus**

MODULE 1

Semiconductor fabrication: Introduction to clean room processing technologies, Thermal oxidation, RTP and furnaces, Fundamentals of lithography: contrast, resist, masks, multiple exposure, Basics of thin film deposition, PVD (sputtering, evaporation), Epitaxial growth, LPCVD, PECVD, Doping and implantation, Wet etching, Dry etching, Metallization and wire bonding. [5 hours]

Introduction to Semiconductor Packaging: Definition of packaging and its significance in various industries; Introduction to packaging, and its importance in Modern Electronics, Device isolation and packaging Device technology (CMOS, GaAs FET, silicon photonics) Integrated circuit manufacturing (yield, DOE, SPC, etc). leaded and leadless packages, surface mount technology (SMT), and ball grid array (BGA), advanced packaging technologies, such as 2.5D, and 3D packaging. **[6 hours]**

Transport measurements in semiconductors: Thermionic emission theory, Thermionic emission -diffusion theory, Tunnelling current, Space-charge current, Measurement of barrier height: I-V measurements, Activation energy measurement, capacitance-voltage measurement, Photoelectric measurements. **[4 hours]**

MODULE 2

Transport in MOS: Basics of MOS, historical background, applications in modern electronics, Ideal MOS capacitor, Energy bands and charge carriers in MOS structures. Operation and characteristics of the MOS capacitor, band diagrams at equilibrium, accumulation, depletion and inversion, threshold voltage, body effect, MOSFET-structure, types, Drain current equation (derive)- linear and saturation region, Drain characteristics, transfer characteristics. **[6 hours]**

Scaling effect in MOS: Scaling trends in MOS technology, MOSFET scaling – need for scaling, constant voltage scaling and constant field scaling. Sub threshold conduction in MOS. **[3 hours]**

Short channel effect in MOS: Short channel effects- Channel length modulation, Drain Induced Barrier Lowering, Velocity Saturation, Threshold Voltage Variations and Hot Carrier Effects. Non-Planar MOSFETs: Fin FET –Structure, operation and advantages. **[3 hours]**

Introduction to VLSI: Concepts of analog VLSI and mixed-signal issues in CMOS technologies, VLSI Design Flow: Design Hierarchy, VLSI Design Styles, levels of abstraction, challenges of VLSI design. **[3 hours]**

5.0 DETAILED CONTENTS OF THE COURSE: PRACTICUM

Credit: 2	**Laboratory Work: 60 Hours**

In this course, the students will learn the operation of test equipment and measurement techniques. The students will be able to efficiently troubleshoot and fix incorrect settings and can reliably measure data with limited errors. It will also help them to perform routine calibrations of the equipment.

Students will be able to conduct experiments and collect and record data. In particular, the students will be able to use techniques to minimize errors and eliminate artefacts, to troubleshoot hardware to collect sufficient data (both in terms of quantity and quality) to achieve lab goals, to demonstrate comprehensive and well-organized records, and to establish conclusive robust results.

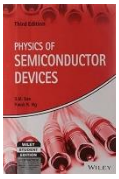
The teacher has the flexibility to introduce a wide range of laboratory experiments that directly correlate with and reinforce the theoretical concepts covered in the course curriculum. These experiments serve as practical applications of the theoretical principles discussed in lectures.

Suggestive list of experiments:

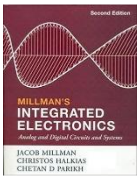
1. To study the capacitance at metal-semiconductor junctions and its dependency on temperature.
2. To study the voltage dependent transport mechanisms of a pn-junction diode
3. To study the voltage dependent transport mechanisms of a metal-semiconductor Schottky junction.
4. To study the photocurrent variation with applied bias under different frequencies and different intensities.
5. To study the space charge limited current and understanding of different regimes of conductivity like mobility, ballistics and trap-filled regimes.

6. To estimate the activation energy from temperature dependent current-voltage characteristics of an metal-semiconductor junction.
7. I-V measurements on MOS devices - Analyze the electrical characteristics (threshold voltage, on/off current, transconductance).
8. Perform C-V measurements on MOS devices - Vary process parameters during fabrication and observe the effects on device performance.
9. Determination of drain, source and gate current of MOSFET working in common source biasing circuit.
10. Determination of small signal current gain of a MOSFET source follower circuit.
11. Realize a MOSFET as a current mirror.
12. Study the I_{DS} vs. V_{DS} characteristic of an n-channel MOSFET and determine the channel conductance.
13. Study the MOSFET characteristics to analyse drain conductance as a function of V_{GS}, channel resistance, as a function of V_{DS} and transconductance as a function of V_{GS}.
14. Examine the performance of advanced MOS structures.
15. Build and test simple circuits using MOS devices.
16. Simulate MOS device performance using software tools.

6.0 TEXT BOOKS

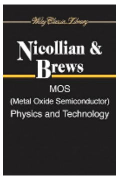


Name: Physics of Semiconductor Devices
Author: S. M. Sze, Kwok K. Ng
Edition: 2010
Publisher: Wiley
ISBN: 978-8126517022

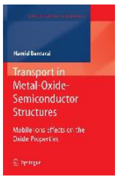


Name: . Integrated Electronics
Author: Jacob Millman, Christos Halkias and Chetan Parikh
Edition: 2011
Publisher: McGraw Education .
ISBN: Integrated Electronics

7.0 REFERENCE BOOKS AND MATERIALS



Name: MOS (Metal Oxide Semiconductor) Physics and Technology
Author: E. H. Nicollian, J. R. Brews
Edition: 1982
Publisher: Wiley
ISBN: 978-0471430797



Name: Transport in Metal-Oxide-Semiconductor Structures
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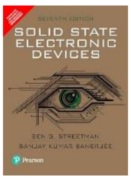
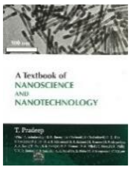


Name: Solid State Electronics Devices,
Author: B.G. Streetman, S. K. Banerjee
Edition: 2016
Publisher: Pearson
ISBN: 978-0131497269



Name: A Textbook of Nanoscience and Nanotechnology
Author: T. Pradeep
Edition: 2017
Publisher: McGraw Hill
ISBN: 978-1259007323

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CO3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

9.0 ASSESSMENT SCHEME

The evaluation system for this course consists of an 80% weightage on a comprehensive theory examination, which assesses students' understanding of various course topics, and a 20% weightage allocated to internal assessments, including internal examinations, assignments, class participation, and overall engagement in the course throughout the semester.

THEORY:

(A) Internal assessment: (20 marks): Continuous evaluation and internal assessment are implemented to foster and maintain a thorough understanding throughout the learning process. By regularly assessing comprehension through assignments, quizzes, and class participation, educators can address learning gaps promptly and support students in achieving deeper knowledge and proficiency in the subject matter.

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Activity	Marks
Laboratory work in the Examination	40
Laboratory Notebook	20
Presentation/Viva-voce	20

PHY - 001- DE - 42220: ELECTRO-OPTICS AND OPTO-ELECTRONICS

NCrF Level:	6.0		
Programme:	Four Year Undergraduate Programme	**Semester:**	Eighth
Course Category:	Major Course (Departmental Elective)		
Credit (L: T: P)	2: 0: 2		
Credit Hours	Theory: 30 Hours, Practicum: 60 Hours		

1.0 COURSE LEARNING OBJECTIVES

This course reviews the concepts of electron-optical phenomenon and optoelectronic properties. It starts with the influence of optical input on electrical properties. The course also provides an in depth understanding of optoelectronic phenomenon in terms of charge carrier generation, separation etc.

2.0 COURSE LEARNING OUTCOME

After completing this course, students will be able to,

CO	Outcomes
CO1:	Understand the features of optical crystals.
CO2:	Basic knowledge on the influence of light and temperature on electrical properties.
CO3:	Understanding the operation of diverse kind of optical modulators.
CO4:	Understanding the operation and output characteristics of LEDs.
CO5:	Idea about the application of quantum structures in LEDs/lasers
CO6:	Understanding of photodetection and working principle of different photodetectors
CO7:	Knowledge about solar cell technology and solar cell parameters.
CO8:	Use of spectrometer and lasers, and necessary precautions during the experiments.
CO9:	Sessions on the review of experimental data analysis, and writing of scientific laboratory reports including proper reporting of errors.
CO10:	Presentation of experimental methods and data in a laboratory report.

3.0 SKILLS TO BE LEARNED

- Hand on experience with various light sources and spectrometers.
- Arrangement of optics related experimental set-up.
- Data analysis, error calculation and laboratory report preparation.

4.0 DETAILED CONTENTS OF THE COURSE: THEORY

Credit: 3 **Classroom Teaching: 45 Horus**

MODULE 1

Crystal Optics: Neumann's principle, tensors, first-order electro-optical tensor, piezo-optical and elasto-optical tensors, dielectric description of a crystal, double refraction, polarization devices, crystal of LiNBO3, KDP and BaTiO3. **[4 hours]**

Optical influence on electrical properties: Electro-optic effect, linear and quadratic electro-optic effect, physical properties of electro-optic coefficients, retardation, electro-optic effect based amplitude and phase modulation, electro-optic effect in KDP and cubic crystals, Light-Induced Refractive Index Changes, Kerr effect, Thermo-optic Effect **[6 hours]**

Modulators: Electro-optic modulators, Photorefractive effect, Two beam coupling in Photorefractive materials, Four wave mixing in Photorefractive materials. Electro-optic (EO) light modulators – EO Fabry-Perot modulators – bistable EO devices. **[5 hours]**

MODULE 2

Light Emitting Diode: LED structures, light current characteristics and device performance, frequency response and modulation band width, device configuration and efficiency. Lasing actin in diode - Laser diode - Structure and operation, edge-emitting and vertical-cavity surface-emitting laser, heterojunction and injection lasers, output characteristics. Quantum dot, wire and well lasers. **[6 hours]**

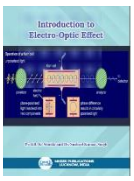
Photodetectors and Solar Cell: Photodetector and related parameters: quantum efficiency, responsivity, photoconductors and photodiodes, Types of photodetectors: p-n junction photodiodes, avalanche photodiodes, and Schottky photodetectors, PIN diodes, heterojunction diodes, high speed measurement photoresistors, CCDs, photomultiplier tube, noises in photodetectors. solar cell research: technology Silicon, Organic ideal cell under illumination solar cell parameters, optical losses; electrical losses, surface recombination velocity, quantum efficiency - measurements of solar cell parameters; I-V curve & L-I-V characteristics, internal quantum yield measurements – effects of series and parallel resistance and temperature - loss analysis.

5.0 DETAILED CONTENTS OF THE COURSE: PRACTICUM

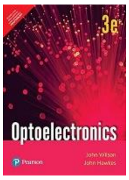
Credit: 2 **Laboratory Work: 60 Hours**

1. To study the Kerr effect.
2. To study the conductivity of semiconductors under light illumination.
3. To study the variation of dialectic property of material under light illumination.
4. To study the characteristics of Light emitting diodes of various types.
5. To study the characteristics of photoresistor.
6. To study the characteristics of PIN photodiode.
7. To study the distance vs photocurrent characteristics of LDR, Photodiode and Phototransistor.
8. To study the characteristics of heterojunction photodiode.
9. To study the characteristics of charged coupled devices.
10. To study the characteristics of photo-transistor.
11. To study the characteristics of photomultiplier tube.
12. To study the characteristics of solar cell.
13. To study the effect of effects of series and parallel resistance in solar cell.
14. To study the effect of temperature on the performance of solar cell.
15. Study the efficacy and loss in solar cell.
16. Determination of the transfer characteristics curve of the Optocoupler.

6.0 TEXT BOOKS

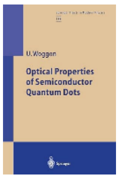


Name: Introduction to Electro-Optic Effect
Author: R. K. Shukla, Susheel Kumar Singh
Edition:
Publisher: MKSES Publications
ISBN: 9789391248741

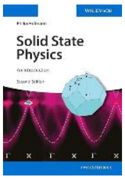


Name: Optoelectronics
Author: John Wilson, John Hawkes
Edition: 3rd Ed
Publisher: Pearson Education
ISBN: 978-9352866663

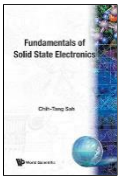
7.0 REFERENCE BOOKS AND MATERIALS



Name: Optical Properties of Semiconductors
Author: U.Woggon
Edition: 1st (1997)
Publisher: Springer-Verlag
ISBN: 978-3662148129



Name: Solid State Physics: An Introduction
Author: Philip-Hofmann
Edition: 2nd Ed.
Publisher: Weinheim, Germany
ISBN: 978-3527412822



Name: Fundamentals of Solid-State Electronics
Author: Chih-Tang Sah and T. C. McGill
Edition: 1991
Publisher: World Scientific Publishing Co Pte Ltd
ISBN: 978-9810206383

6.0 MAPPING OF CLO TO PO AND PSO

The course outcomes and their mapping with program outcomes are specified in the table below

Course Learning Outcomes	Programme Outcomes (POs)												Programme Specific Outcome (PSOs)					
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6
CO1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

9.0 ASSESSMENT SCHEME

The evaluation system for this course consists of an 80% weightage on a comprehensive theory examination, which assesses students' understanding of various course topics, and a 20% weightage allocated to internal assessments, including internal examinations, assignments, class participation, and overall engagement in the course throughout the semester.

THEORY:

(A) Internal assessment: (20 marks): Continuous evaluation and internal assessment are implemented to foster and maintain a thorough understanding throughout the learning process. By regularly assessing comprehension through assignments, quizzes, and class participation, educators can address learning gaps promptly and support students in achieving deeper knowledge and proficiency in the subject matter.

(B) End-term examination (80 marks): The end-term examination serves as a culmination of students' learning in the course, assessing their comprehensive understanding and proficiency in various topics in the course. It provides a structured platform for students to demonstrate their knowledge, problem-solving abilities, and application of theoretical concepts, ultimately gauging their readiness to progress. Pattern of End term question paper

Section	Total Questions	Marks for each question	have to attempt	Total Marks
A	5	4	4	20
B	5	10	3	30
C	4	15	2	30

PRACTICUM:

(A) Internal assessment: (20 marks): In the internal assessment of the practicum components, the student's performance, understanding, skills, sincerity, and involvement in laboratory work during the entire semester are evaluated.

(B) End-term examination (80 marks): The ability to apply theoretical knowledge to real-world situations is the fundamental criterion used in the End Term examination. It typically involves students' activity on randomly assigned laboratory works and the Laboratory Report (Notebook) on the performed work in the entire semester. In the End examination, the student must complete randomly assigned tasks and prepare a report on their work, including appropriate conclusions. The mark distribution for the End term examination as follows.

Activity	Marks
Laboratory work in the Examination	40
Laboratory Notebook	20
Presentation/Viva-voce	20

PHY - 001- DE - 42230: NON-EQUILIBRIUM STATISTICAL MECHANICS

PHY - 001- DE - 42260: PROPERTIES OF CONDENSED MATTER

PHY - 001- DE - 42300: PARTICLE PHYSICS

MINOR COURSES

PHY 001 MC 1110: MECHANICS AND PROPETIES OF MATTER

NCrF Level:	4.5	
Programme:	Four Year Undergraduate Programme	**Semester:** First
Course Category:	Minor Course	
Credit (L: T: P)	3: 0: 1	
Credit Hours	Theory: 45 Hours, Practical 30 Hours	

1.0 COURSE LEARNING OBJECTIVES

The course is to develop a basic understanding of the fundamental principles of mechanics as well as basic properties of matter like elasticity, viscosity and surface tension.

- Understand and articulate core principles of mechanics, including Newton's laws of motion, energy conservation, and the dynamics of particles and rigid bodies.
- Apply mechanics principles to analyse and solve complex problems involving forces, motion, energy, and momentum in various mechanical systems.
- Evaluate the mechanical behaviour of systems, including translational and rotational motion, using principles of kinematics and dynamics.
- Equip students with the understanding and ability to analyse elasticity, viscosity, and surface tension in various materials, and apply these principles to solve practical engineering and scientific problems.

2.0 COURSE LEARNING OUTCOME

After completing this course, students will be able to,

CO	Outcomes
CO1:	Understand the fundamentals of dynamics along with the concept of the reference frame and to solve real world physical problems
CO2:	Understand the phenomena of collisions and ideas about centre of mass and laboratory frames and their correlation.
CO3:	Understand the analogy between translational and rotational dynamics along with the of moment of inertia as well as to calculate moment of inertia for different mass distributions
CO4:	Understand about the Gravitation in the universe and Kepler's law to describe the motion of planets and satellites in circular orbit along with their applications
CO5:	Understand the theory behind material deformation under stress, the concept of concepts of elastic constants and its applications.
CO6:	Learn the principle of liquid and viscosity including governing laws and theorems and its applications in actual circumstances.
CO7:	Understand about the forces at the surface of liquids, concept of surface tension and its effect in day-to-day applications.
CO8:	Skill in using different measuring instruments in the laboratory with necessary precautions and their applications to study the laws of mechanics and properties of matters.
CO9:	Able to prepare clear, structured, and concise scientific reports, effectively presenting laboratory works and findings with enhanced clarity.

3.0 SKILLS TO BE LEARNED

- Learn basics of the kinematics and dynamics linear and rotational motion.
- Develop skills to understand and solve the equations of central force problems.
- Learn the concepts of elastic in constant solids and viscosity of fluids.
- Use of various types of measuring instruments used in Physics Laboratories.
- Skill to use of graph between two different physical quantities to calculate an unknown quantity.
- Art of scientific report wringing of laboratory work.

4.0 DETAILED CONTENTS OF THE COURSE: THEORY

Credit: 3 **Classroom Teaching: 45 Hours**

MODULE 1

Vectors: Vector algebra. Scalar and vector products, gradient of a scalar field, divergence and curt of a vector field. **[3 hours]**

Ordinary Differential Equations: First order homogeneous differential equations. 2^{nd} order homogeneous differential equations with constant coefficients. **[5 hours]**

Fundamentals of Dynamics: Dynamics of a system of particles, centre of mass, determination of centre of mass for discrete and continuous systems having spherical symmetry, Conservation of momentum and energy, Conservative and non-Conservative forces, work – energy theorem for conservative forces, force as a gradient of potential energy, Motion of rockets. **[7 hours]**

MODULE 2

Rotational Dynamics: Angular velocity, angular momentum, torque, conservation of angular momentum, Moment of inertia, Theorem of parallel and perpendicular axes, Calculation of moment of inertia of discrete and continuous objects (1-D and 2-D). **[5 hours]**

Gravitation: Newton's Law of Gravitation. Motion of a particle in a central force field, two body problem Kepler's Laws (statement only). Satellite in circular orbit and applications. Geosynchronous orbits. **[5 hours]**

Oscillation and waves: Idea of simple harmonic motion, Differential equation of simple harmonic motion and its solution, Motion of a simple pendulum and compound pendulum **[5 hours]**

MODULE 3

Elasticity: Concept of stress and strain, Hooke's law, elastic moduli, twisting torque on a wire, tensile strength, relation between elastic constants, Poisson's ratio, rigidity modulus **[3 hours]**

Viscosity: Rate flow of liquid in a capillary tube - Poiseuille's formula - Determination of coefficient of viscosity of a liquid, Variations of viscosity of liquid with temperature- lubrication. **[3 hours]**

Surface Tension: Synclastic and anticlastic surface - Excess of pressure -Application to spherical and cylindrical drops and bubbles - variation of surface tension with temperature - Jaegar's method. **[3 hours]**

Special Theory of Relativity: Postulates of Special Theory of Relativity, Lorentz transformation, length contraction, time dilation, relativistic transformation of velocity, relativistic variation of mass, mass-energy equivalence **[6 hours]**

5.0 DETAILED CONTENTS OF THE COURSE: PRACTICUM

Credit: 1 **Laboratory Work: 30 Hours**

In the practicum component of the course, students will undergo a number of experiments related to motion of objects and properties of materials. During the experiment students will undergo precise measurement of physical parameters and analysis of the measured data to determine different physical quantities. Initially students have to familiarize themselves with the use of different measuring instruments as mentioned in the section (A). Here are some of the key measuring instruments

Students are required to conduct experiments from the provided list, meticulously following the suggested procedures and protocols outlined for each. Subsequently, they must compile comprehensive reports for every experiment, adhering to scientific standards and conventions. These reports should encompass a detailed description of the experimental setup and methodology employed, including any modifications made during the course of the experiment. Furthermore, students are expected to record and analyze their experimental data systematically, drawing upon relevant theoretical concepts and principles to interpret their findings accurately. Additionally, the reports should include a thorough discussion of the results obtained, highlighting any observed trends, anomalies, or correlations, and offering insightful explanations or hypotheses where applicable. Moreover, students must demonstrate proficiency in presenting their results graphically, utilizing tables, figures, and diagrams to enhance clarity and facilitate comprehension. Finally, each report should conclude with a succinct summary of the key findings and conclusions drawn from the experiment, along with any recommendations for further investigation or improvement.

The teacher has the flexibility to introduce a wide range of laboratory experiments that directly correlate with and reinforce the theoretical concepts covered in the course curriculum. These experiments serve as practical applications of the theoretical principles discussed in lectures.

Laboratory activity and skills:

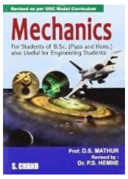
- To Draw the curve of the functions - linear, quadric, polynomial, algebraic, transcendental, trigonometric, exponential, and hyperbolic functions in graph paper
- To calculate mean values, standard deviations, and percentage errors for a set of data and to evaluate the accuracy and precision of the data
- Use of Vernier calipers to measure (i) the diameter of a small spherical/cylindrical body (ii) the internal diameter and depth of a given cylindrical object like beaker.
- Use of screw gauge to measure (i) diameter of a given wire and (ii) thickness of a given sheet
- Use of a Sextant for the measurement of height of a building
- Use of a traveling microscope for the accurate measurement of small gap
- Use of spherometer to determine the radius of curvature of a given spherical surface
- Methods for precise measurement using measuring Tape, sprit level, stopwatch, Spring Balance and laboratory balance.
- To study the random error in observations.

List of experiments:

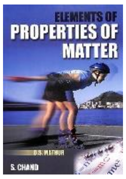
1. Measurement of the weight of a given body (a wooden block) using the parallelogram law of vector addition.
2. To study the relation between force of limiting friction and normal reaction and to find the coefficient of friction between surface of a moving block and that of a horizontal surface.
3. To find the downward force, along an inclined plane, acting on a roller due to gravity and study its relationship with the angle of inclination by plotting graph between force and angle.
4. Using a Simple Pendulum plot and graphs, find the effective length of second's pendulum using appropriate graph
5. To determine g and velocity for a freely falling body using Digital digital Technique.
6. To determine the Moment of Inertia of a Flywheel about its own axis of rotation
7. To determine the value of acceleration due to gravity with the help of a Bar pendulum.
8. To determine the value of acceleration due to gravity with the help of a Kater's Pendulum
9. To determine the moment of inertia of a given body by means of inertia table and the help of an auxiliary body whose moment of inertia can be calculated from its dimensions.
10. To determine Young's modulus of the material of a given wire by using Searle's apparatus

11. To determine the Young's Modulus of a Wire by Optical Lever Method
12. To determine the Modulus of Rigidity of a Wire by Maxwell’s needle.
13. Determination of Young’s Modulus, Rigidity Modulus and Poisson ratio of a wire by Searle’s method.
14. Determination of Young’s Modulus of the material of a beam by the Koeing’s method (method of bending)
15. To verify Stokes’ law and hence to determine the coefficient of viscosity of a liquid.
16. Determination of the coefficient of viscosity of liquid by its flow through a capillary tube (Poiseuille’s method)
17. To determine Coefficient of Viscosity of water by Capillary Flow Method (Poiseuille’s method).
18. To determine the surface tension of water by capillary rise method and verification of Jurin’s Law.
19. Determination of Surface Tension of a liquid-by-liquid drop method.
20. Determination of surface tension of liquid with temperature by Jaegar’s method.

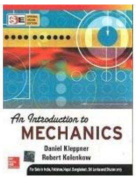
6.0 TEXT BOOKS



Name: Mechanics
Author: D.S. Mathur
Edition: 2000
Publisher: S. Chand & Company Ltd.
ISBN: 978-8121905992



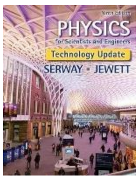
Name: Properties of Matter
Author: D.S. Mathur
Edition: 2010
Publisher: S. Chand & Company Ltd.
ISBN: 978-8121908153



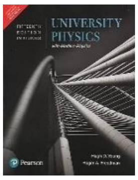
Name: Properties of Matter
Author: D. Kleppner, R.J. Kolenkow
Edition: 2017
Publisher: McGraw Hill Education
ISBN: 978-0070647787

7.0 REFERENCE BOOKS AND MATERIALS

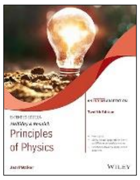
Name: Mechanics, Berkeley Physics, vol.1
Author: C.Kittel, W.Knight
Edition: 2nd Ed.
Publisher: McGraw-Hill Education, India
ISBN: 978-0070702134



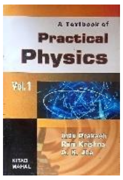
Name: Physics for scientists and Engineers with Modern Physics
Author: J.W. Jewett, R.A. Serway,
Edition: 9th Ed.
Publisher: Brooks/Cole
ISBN: 978-1305116399



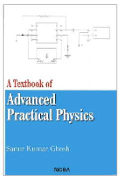
Name: University Physics
Author: Ronald Lane Reese
Edition: 7th Edn
Publisher: Pearson Education
ISBN: 978-9353949297



Name: University Physics
Author: Ronald Lane Reese
Edition: 20th Ed.
Publisher: Wiley India Private Limited
ISBN: 978-9357460835



Name: A textbook of Practial Physics
Author: Indu Prakash, Rama Krishna, A.K. Jha
Edition: 2011
Publisher: Kitab Mahal
ISBN: 978-8122504163



Name: A Textbook of Advanced Practical Physics
Author: Samir Kumar Ghosh
Edition: 2008
Publisher: New Central Book Agency
ISBN: 978-8173812439

86.0 MAPPING OF CLO TO PO AND PSO

The course outcomes and their mapping with program outcomes are specified in the table below

Course Learning Outcomes	Programme Outcomes (POs)												Programme Specific Outcome (PSOs)					
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6
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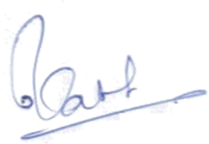
CO2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

9.0 ASSESSMENT SCHEME

The evaluation system for this course consists of an 80% weightage on a comprehensive theory examination, which assesses students' understanding of various course topics, and a 20% weightage allocated to internal assessments, including internal examinations, assignments, class participation, and overall engagement in the course throughout the semester.



THEORY:

(A) Internal assessment: (20 marks): Continuous evaluation and internal assessment are implemented to foster and maintain a thorough understanding throughout the learning process. By regularly assessing comprehension through assignments, quizzes, and class participation, educators can address learning gaps promptly and support students in achieving deeper knowledge and proficiency in the subject matter.

(B) End-term examination (80 marks): The end-term examination serves as a culmination of students' learning in the course, assessing their comprehensive understanding and proficiency in various topics in the course. It provides a structured platform for students to demonstrate their knowledge, problem-solving abilities, and application of theoretical concepts, ultimately gauging their readiness to progress. Pattern of End term question paper

Section	Total Questions	Marks for each question	have to attempt	Total Marks
A	5	4	4	20
B	5	10	3	30
C	4	15	2	30

PRACTICUM:

(A) Internal assessment: (20 marks): In the internal assessment of the practicum components, the student's performance, understanding, skills, sincerity, and involvement in laboratory work during the entire semester are evaluated.

(B) End-term examination (80 marks): The ability to apply theoretical knowledge to real-world situations is the fundamental criterion used in the End Term examination. It typically involves students' activity on randomly assigned laboratory works and the Laboratory Report (Notebook) on the performed work in the entire semester. In the End examination, the student must complete randomly assigned tasks and prepare a report on their work, including appropriate conclusions. The mark distribution for the End term examination as follows.

Activity	Marks
Laboratory work in the Examination	40
Laboratory Notebook	20
Presentation/Viva-voce	20

PHY 001 MC 1210: WAVE AND OPTICS

NCrF Level:	4.5	
Programme:	Four Year Undergraduate Programme	**Semester:** Second
Course Category:	Minor Course	
Credit (L: T: P)	3: 0: 1	
Credit Hours	Theory: 45 Hours, Practical 30 Hours	

1.0 COURSE LEARNING OBJECTIVES

This course reviews the concepts of waves and optics learnt at school from a more advanced perspective and goes on to build new concepts The Learning Objectives of the Course are:

- Understand and analyze oscillatory motion, including simple harmonic motion and its applications
- Explore the propagation of sound waves, including factors affecting intensity, frequency
- Understand the fundamental nature and properties of light
- Utilize wave optics concepts to explain interference, diffraction, and polarization.

2.0 COURSE LEARNING OUTCOME

After completing this course, students will be able to,

CO	Outcomes
CO1:	Recognize and use a mathematical oscillator equation and wave equation, and derive these equations for certain systems.
CO2:	Understand the principle of superposition of waves, so thus describe the formation of standing waves and it applications.
CO3:	Apply basic knowledge of principles and theories about the behaviour of light and the physical environment to conduct experiments
CO4:	Gain a comprehensive understanding of interference of light and it's use to explain the operation in various optical components and systems.
CO5:	Acquire principles and mathematical formulations of diffraction and applications in optics to enable in analysing and designing optical systems with diffraction effects effectively.
CO6:	Understand the phenomena of polarization phenomena, and to analyse as well as to manipulate polarization effects in different optical components and devices effectively.
CO7:	Gained practical skills in optical experimentation along with analysing data, and applying theoretical concepts to real-world scenarios
CO8:	Able to prepare clear, structured, and concise scientific reports, effectively presenting laboratory works and findings with enhanced clarity.

3.0 SKILLS TO BE LEARNED

- To analyze oscillatory phenomena, including simple harmonic motion, damping, and resonance.
- to analyze wave properties such as frequency, wavelength, amplitude
- To analysis propagation of sound waves and their characteristics as well as Doppler effect.,
- To explain the variation of behaviour of light in nature under different circumstance.
- To distinguish between reflection, inference, diffraction and polarization of light in nature.
- To use different optical components along with required safety considerations.

4.0 DETAILED CONTENTS OF THE COURSE: THEORY

Credit: 3 **Classroom Teaching: 45 Hours**

MODULE 1

Superposition of Harmonic Oscillations: Simple harmonic motion (SHM). Linearity and Superposition Principle. Superposition of two collinear harmonic oscillations having (1) equal frequencies and (2) different frequencies (Beats). Superposition of two perpendicular harmonic oscillations: Graphical and Analytical Methods. Lissajous Figures (1:1 and 1:2) and their uses **[10 hours]**

Waves Motion: Types of waves: Longitudinal and Transverse (General idea). Travelling waves in a string, wave equation. Energy density. Standing waves in a string - modes of vibration. Group velocity, Phase velocity, plane waves, spherical waves, wave intensity **[5 hours]**

MODULE 2

Sound: damped vibration, forced vibrations and resonance - Fourier's Theorem - Application to saw tooth wave and square wave - Intensity and loudness of sound - Decibels - Intensity levels - musical notes - musical scale. Acoustics of buildings: Reverberation and time of reverberation **[5 hours]**

Interference of Light: Electromagnetic nature of light, Huygens Principle. Interference: Division of amplitude and division of wave front. Young's Double Slit experiment. Lloyd's Mirror and Fresnel's Biprism, Phase change on reflection: Stoke's treatment. Interference in Thin Films: parallel and wedge-shaped films. Fringes of equal inclination (Haidinger Fringes); Fringes of equal thickness (Fizeau Fringes). Newton's Rings: measurement of wavelength and refractive index **[10 hours]**

MODULE 3

Michelson's Interferometer: Idea of form of fringes (no theory needed), Determination of wavelength, Wavelength difference, Refractive index, and Visibility of fringes. **[3 hours]**

Diffraction: Fraunhofer diffraction- Single slit; Double Slit. Multiple slits and Diffraction grating. Fresnel Diffraction: Half-period zones. Zone plate. Fresnel Diffraction pattern of a straight edge, a slit and a wire using half-period zone analysis. **[10 hours]**

Polarization: Transverse nature of light waves. Plane polarized light – production and analysis. Circular and elliptical polarization. **[2 hours]**

5.0 DETAILED CONTENTS OF THE COURSE: PRACTICUM

Credit: 1 **Laboratory Work: 30 Hours**

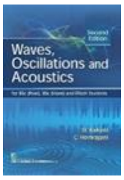
In the practicum component of the course, students will undergo a number of experiments related to waves and optical phenomena. Students are required to conduct experiments from the provided list, meticulously following the suggested procedures and protocols outlined for each. Subsequently, they must compile comprehensive reports for every experiment, adhering to scientific standards and conventions. These reports should encompass a detailed description of the experimental setup and methodology employed, including any modifications made during the course of the experiment. Furthermore, students are expected to record and analyze their experimental data systematically, drawing upon relevant theoretical concepts and principles to interpret their findings accurately. Additionally, the reports should include a thorough discussion of the results obtained, highlighting any observed trends, anomalies, or correlations, and offering insightful explanations or hypotheses where applicable. Moreover, students must demonstrate proficiency in presenting their results graphically, utilizing tables, figures, and diagrams to enhance clarity and facilitate comprehension. Finally, each report should conclude with a succinct summary of the key findings and conclusions drawn from the experiment, along with any recommendations for further investigation or improvement.

The teacher has the flexibility to introduce a wide range of laboratory experiments that directly correlate with and reinforce the theoretical concepts covered in the course curriculum. These experiments serve as practical applications of the theoretical principles discussed in lectures.

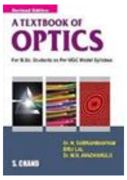
List of experiments:

1. To investigate the motion of coupled oscillators
2. To determine the Frequency of an Electrically Maintained Tuning Fork by Melde's Experiment and to verify λ^2 – T Law.
3. To study Lissajous Figures
4. Familiarization with Schuster`s focussing; determination of angle of prism.
5. To determine the Coefficient of Viscosity of water by Capillary Flow Method (Poiseuille's method).
6. To determine the Refractive Index of the Material of a Prism using Sodium Light.
7. To determine Dispersive Power of the Material of a Prism using Mercury Light
8. To determine the value of Cauchy Constants.
9. To determine the Resolving Power of a Prism.
10. To determine wavelength of sodium light using Fresnel Biprism.
11. To determine wavelength of sodium light using Newton's Rings.
12. To determine the wavelength of Laser light using Diffraction of Single Slit.

6.0 TEXT BOOKS

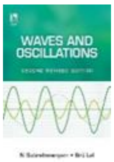


Name: Waves Oscillations and Acoustics
Author: S.L. Kakani and C Hemrajani
Edition: 2nd (2018)
Publisher: CBS publishers
ISBN: 978-9386827814

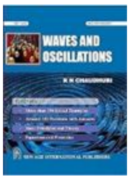


Name: A Textbook of Optics
Author: Brij Nandan Lal and N. Subrahmanyam
Edition: 23 Ed.
Publisher: S. Chand
ISBN: 978-8121926119

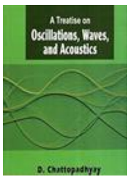
7.0 REFERENCE BOOKS AND MATERIALS



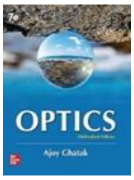
Name: Waves And Oscillations
Author: N. Subrahmanyam, Brij Lal
Edition: 2nd Ed.
Publisher: Vikas Publishing House Pvt Ltd
ISBN: 978-0706985436



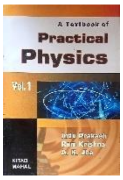
Name: Waves and Oscillations
Author: R. N. Chaudhuri
Edition: 2010
Publisher: New Age Publishers
ISBN: 978-8122426793



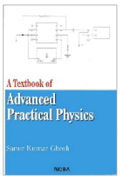
Name: A Treatise on Oscillations, Waves and Acoustics
Author: D Chattopadhyay
Edition:
Publisher:
ISBN: 978-9384294748



Name: Optics
Author: Ajoy Ghatak
Edition: 7th Ed.
Publisher: McGraw Hill
ISBN: 978-9390113590



Name: A textbook of Practial Physics
Author: Indu Prakash, Rama Krishna, A.K. Jha
Edition: 2011
Publisher: Kitab Mahal
ISBN: 978-8122504163



Name: A Textbook of Advanced Practical Physics
Author: Samir Kumar Ghosh
Edition: 2008
Publisher: New Central Book Agency
ISBN: 978-8173812439

86.0 MAPPING OF CLO TO PO AND PSO

The course outcomes and their mapping with program outcomes are specified in the table below

Course Learning Outcomes	Programme Outcomes (POs)												Programme Specific Outcome (PSOs)					
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6
CO1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

9.0 ASSESSMENT SCHEME

The evaluation system for this course consists of an 80% weightage on a comprehensive theory examination, which assesses students' understanding of various course topics, and a 20% weightage allocated to internal assessments, including internal examinations, assignments, class participation, and overall engagement in the course throughout the semester.

THEORY:

(A) Internal assessment: (20 marks): Continuous evaluation and internal assessment are implemented to foster and maintain a thorough understanding throughout the learning process. By regularly assessing comprehension through assignments, quizzes, and class participation, educators can address learning gaps promptly and support students in achieving deeper knowledge and proficiency in the subject matter.

(B) End-term examination (80 marks): The end-term examination serves as a culmination of students' learning in the course, assessing their comprehensive understanding and proficiency in various topics in the course. It provides a structured platform for students to demonstrate their knowledge, problem-solving abilities, and application of theoretical concepts, ultimately gauging their readiness to progress. Pattern of End term question paper

Section	Total Questions	Marks for each question	have to attempt	Total Marks
A	5	4	4	20
B	5	10	3	30
C	4	15	2	30

PRACTICUM:

(A) Internal assessment: (20 marks): In the internal assessment of the practicum components, the student's performance, understanding, skills, sincerity, and involvement in laboratory work during the entire semester are evaluated.

(B) End-term examination (80 marks): The ability to apply theoretical knowledge to real-world situations is the fundamental criterion used in the End Term examination. It typically involves students' activity on randomly assigned laboratory works and the Laboratory Report (Notebook) on the performed work in the entire semester. In the End examination, the student must complete randomly assigned tasks and prepare a report on their work, including appropriate conclusions. The mark distribution for the End term examination as follows.

Activity	Marks
Laboratory work in the Examination	40
Laboratory Notebook	20
Presentation/Viva-voce	20

PHY 001 MC 2110: ELECTRICITY AND MAGNETISM

NCrF Level:	5.0	
Programme:	Four Year Undergraduate Programme	**Semester:** Third
Course Category:	Minor Course	
Credit (L: T: P)	3: 0: 1	
Credit Hours	Theory: 45 Hours, Practical 30 Hours	

1.0 COURSE LEARNING OBJECTIVES

The course aims to provide students with a thorough understanding of the fundamental principles of electricity and magnetism, including electric fields, magnetic fields, and electric currents. The Learning Objectives of the course are:

- Understand the concept of electric fields to solve electrostatics problems.
- Analyze the behavior of conductors, dielectrics, and capacitance in various configurations.
- Explain the principles of magnetostatics and analyze the behavior of magnetic materials.
- Understand and apply Faraday's law of induction
- Fundamental of Maxwell's equations and electromagnetic waves.
- Solve problems involving electric currents, Ohm's law, and circuits.
- Perform and interpret laboratory experiments related to electric and magnetic fields, circuits, and electromagnetism.

2.0 COURSE LEARNING OUTCOME

After completing this course, students will be able to,

CO	Outcomes
CO1:	Understand the concept of vector integrals like line, surface, and volume integrals and theorem interrelating these integrals and their applications.
CO2:	Learn the principles of electrostatics and associated laws along with the skill to solve problems charge distribution in various geometries as well as their significance in practical scenarios.
CO3:	Understand and to apply the fundamental principles of magnetostatics and the laws associated with it for calculating magnetic fields generated by various current configurations.
CO4:	Able to understand concept of electromatic induction and understanding the principles behind transformers and electric generators.
CO5:	Learn the unification of the fundamental laws into Maxwell's equations, their physical significance and the concept behind the predication of electromatic waves.
CO6:	Learn the fundamental laws and behaviour of circuit elements in DC circuits enabling them to analysis diverse electronic systems with precision.
CO7:	Gain a comprehensive understanding of alternating current (AC) theory and skill to analysis basic ac circuit using phasors, impedance and complex numbers.
CO8:	Develop practical skills to verify different principles of electromagnetic induction and electric circuits to reinforce the theoretical concept in the laboratory.
CO9:	Gain hands-on experience in constructing and testing various DC and AC circuit configurations, reinforcing theoretical concepts and enhancing problem-solving abilities in laboratory.
CO10:	Able to prepare clear, structured, and concise scientific reports, effectively presenting laboratory works and findings with enhanced clarity.

3.0 SKILLS TO BE LEARNED

- To solving problems related to electric and magnetic fields in static situations.
- To frame Maxwell's equations in various contexts
- To apply concepts of electricity and magnetism to practical problems,
- To use electronic measurement instruments.

4.0 DETAILED CONTENTS OF THE COURSE: THEORY

Credit: 3 **Classroom Teaching: 45 Horus**

MODULE 1

Vector Analysis: Review of vector algebra (Scalar and Vector product), gradient, divergence, Curl and their significance, Vector Integration, Line, surface and volume integrals of Vector fields, Gauss-divergence theorem and Stoke's theorem (statement only). **[5 Lectures]**

Electrostatics: Electrostatic Field, electric flux, Gauss's theorem of electrostatics. Applications of Gauss theorem - Electric field due to point charge, infinite line of charge, uniformly charged spherical shell and solid sphere, plane charged sheet, charged conductor. Electric potential as line integral of electric field, potential due to a point charge, electric dipole, uniformly charged spherical shell and solid sphere. Calculation of electric field from potential. Capacitance of an isolated spherical conductor. Parallel plate, spherical and cylindrical condenser. Energy per unit volume in electrostatic field. Gauss's theorem in dielectrics. Parallel plate capacitor filled with dielectric. **[10 Lectures]**

MODULE 2

Magnetostatics: Biot-Savart's law and its applications- straight conductor, circular coil, solenoid carrying current. Divergence and curl of magnetic field. Magnetic vector potential. Ampere's circuital law. Magnetic properties of materials: Magnetic intensity, magnetic induction, permeability, magnetic susceptibility. Brief introduction of dia-, para-and ferro- magnetic materials. **[9 Lectures]**

Electromagnetic Induction: Faraday's laws of electromagnetic induction, Lenz's law, self and mutual inductance, L of single coil, M of two coils. Energy stored in magnetic field. **[3 Lectures]**

Maxwell`s equations and Electromagnetic wave propagation: Equation of continuity, Displacement current, Maxwell's equations, Poynting vector, transverse nature of EM waves, polarization. **[3 Lectures]**

MODULE 3

DC currents: Ohm's Law, Kirchhoff's Voltage Law and Kirchhoff's current laws, current through resistance(R), inductance(L), capacitance(C), combination of R, L and C, Transient analysis – growth and decay of currents in LR circuit, Charging and discharging of capacitor in RC circuits, LCR circuit, discharge of capacitor through pure inductor (LC circuit) – electric oscillation. **[7 Hours]**

AC Circuits: Sinusoidal voltage and current - instantaneous, peak to peak, root mean square and average value, form factor and peak factor, Power and wattless components of AC current, voltage-current relationship in resistor, inductor and capacitor, phasor, complex impedance, AC current in RL, RC circuit and LCR circuit (series and parallel) **[8 Hours]**

5.0 DETAILED CONTENTS OF THE COURSE: PRACTICUM

Credit: 1 **Laboratory Work: 30 Hours**

In the practicum component of the course, students will undergo a number of experiments related to various phenomena of electricity and magnetism.

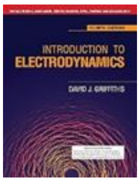
Students are required to conduct experiments from the provided list, meticulously following the suggested procedures and protocols outlined for each. Subsequently, they must compiie comprehensive reports for every experiment, adhering to scientific standards and conventions. These reports should encompass a detailed description of the experimental setup and methodology employed, including any modifications made during the course of the experiment. Furthermore, students are expected to record and analyze their experimental data systematically, drawing upon relevant theoretical concepts and principles to interpret their findings accurately. Additionally, the reports should include a thorough discussion of the results obtained, highlighting any observed trends, anomalies, or correlations, and offering insightful explanations or hypotheses where applicable. Moreover, students must demonstrate proficiency in presenting their results graphically, utilizing tables, figures, and diagrams to enhance clarity and facilitate comprehension. Finally, each report should conclude with a succinct summary of the key findings and conclusions drawn from the experiment, along with any recommendations for further investigation or improvement.

The teacher has the flexibility to introduce a wide range of laboratory experiments that directly correlate with and reinforce the theoretical concepts covered in the course curriculum. These experiments serve as practical applications of the theoretical principles discussed in lectures.

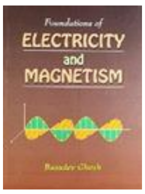
Laboratory activity and List of experiments:

1. To use a Multimeter for measuring (a) Resistances, (b) AC and DC Voltages, (c) DC Current, and (d) checking electrical uses.
2. Use of Ballistic Galvanometer Measurement of charge and current sensitivity
3. Measurement of CDR using Ballistic Galvanometer
4. Determine a high resistance by Leakage Method.
5. To determine Self Inductance of a Coil by Rayleigh's Method.
6. To compare capacitances using De' Sauty's bridge.
7. Measurement of field strength B and its variation in a Solenoid (Determine dB/dx)
8. To study the Characteristics of a Series RC Circuit.
9. To study a series LCR circuit and determine its (a) Resonant frequency, (b) Quality factor
10. To study a parallel LCR circuit and determine its (a) Anti-resonant frequency and (b) Quality factor Q
11. To determine a Low Resistance by Carey Foster's Bridge.
12. To verify the Thevenin and Norton theorems
13. To verify the Superposition, and Maximum Power Transfer Theorems.

6.0 TEXT BOOKS

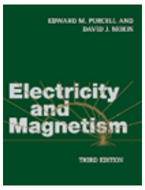


Name: Introduction to Electrodynamics
Author: David J. Griffiths
Edition: 4th Ed. (2020)
Publisher: Cambridge University Press
ISBN: 978-1108822909



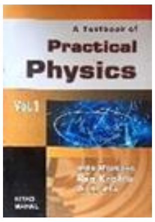
Name: Foundations of Electricity and Magnetism
Author: Basudev Gosh
Edition: 3rd Ed (2008)
Publisher: Books & Allied Ltd
ISBN: 978-8187134084

7.0 REFERENCE BOOKS AND MATERIALS

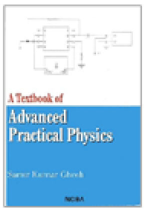


Name: Electricity and Magnetism
Author: Edward M. Purcell and David J. Morin
Edition: 3rd Ed.
Publisher: Cambridge University Press
ISBN: 978-1107014022

Name: Classical Electrodynamics
Author: John David Jackson
Edition: 2020
Publisher: Wiley
ISBN: 978-9388991070



Name: A textbook of Practial Physics
Author: Indu Prakash, Rama Krishna, A.K. Jha
Edition: 2011
Publisher: Kitab Mahal
ISBN: 978-8122504163



Name: A Textbook of Advanced Practical Physics
Author: Samir Kumar Ghosh
Edition: 2008
Publisher: New Central Book Agency
ISBN: 978-8173812439

86.0 MAPPING OF CLO TO PO AND PSO

The course outcomes and their mapping with program outcomes are specified in the table below

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CO2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

9.0 ASSESSMENT SCHEME

The evaluation system for this course consists of an 80% weightage on a comprehensive theory examination, which assesses students' understanding of various course topics, and a 20% weightage allocated to internal assessments, including internal examinations, assignments, class participation, and overall engagement in the course throughout the semester.

THEORY:

(A) Internal assessment: (20 marks): Continuous evaluation and internal assessment are implemented to foster and maintain a thorough understanding throughout the learning process. By regularly assessing comprehension through assignments, quizzes, and class participation, educators can address learning gaps promptly and support students in achieving deeper knowledge and proficiency in the subject matter.

(B) End-term examination (80 marks): The end-term examination serves as a culmination of students' learning in the course, assessing their comprehensive understanding and proficiency in various topics in the course. It provides a structured platform for students to demonstrate their knowledge, problem-solving abilities, and application of theoretical concepts, ultimately gauging their readiness to progress. Pattern of End term question paper

Section	Total Questions	Marks for each question	have to attempt	Total Marks
A	5	4	4	20
B	5	10	3	30
C	4	15	2	30

PRACTICUM:

(A) Internal assessment: (20 marks): In the internal assessment of the practicum components, the student's performance, understanding, skills, sincerity, and involvement in laboratory work during the entire semester are evaluated.

(B) End-term examination (80 marks): The ability to apply theoretical knowledge to real-world situations is the fundamental criterion used in the End Term examination. It typically involves students' activity on randomly assigned laboratory works and the Laboratory Report (Notebook) on the performed work in the entire semester. In the End examination, the student must complete randomly assigned tasks and prepare a report on their work, including appropriate conclusions. The mark distribution for the End term examination as follows.

Activity	Marks
Laboratory work in the Examination	40
Laboratory Notebook	20
Presentation/Viva-voce	30

PHY-001-CC-2210: THERMAL PHYSICS

NCrF Level:	5.0		
Programme:	Four Year Undergraduate Programme	**Semester:**	Fourth
Course Category:	Minor Course		
Credit (L: T: P)	3: 0: 1		
Credit Hours	Theory: 45 Hours, Practical 30 Hours		

1.0 COURSE LEARNING OBJECTIVES

The aim of this course is to provide a comprehensive idea on thermodynamic systems. The Course Learning Objectives are:

- comprehensive understanding of thermodynamic principles, including laws of thermodynamics, thermodynamic potentials, and equilibrium conditions.
- various modes of heat transfer such as conduction, convection, and radiation, and apply these principles to real-world scenarios.
- skills in statistical mechanics to describe the behaviour of systems with many particles, including concepts of entropy, Boltzmann distribution, and partition functions.
- Explore phase transitions in materials, including the study of critical phenomena, phase diagrams, and the behaviour of matter under different thermodynamic conditions.

2.0 COURSE LEARNING OUTCOME

After completing this course, students will be able to,

CO	Outcomes
CO1:	Learn the behaviour of gas molecules in terms of their motion and interactions to apply in explaining macroscopic properties such as volume, pressure, temperature and diffusion.
CO2:	Understand the kinetics of real gasses, including deviations from ideal behaviour, equations of state, critical phenomena analysis and experimental techniques.
CO3:	Learn techniques to analyze and solve problems related to gas behaviour using mathematical models derived from the kinetic theory in real work physical problems.
CO4:	Learn the principles of thermal equilibrium and temperature measurement through the Zeroth Law of Thermodynamics and its use in analysis of thermodynamic problems.
CO5:	Understand the concepts of energy conservation, internal energy, heat, and work on the basis of the first law of thermodynamics as well as to apply these in real work systems.
CO6:	Learn principles of entropy, irreversibility of natural processes as defined by the Second Law of Thermodynamics which enable them to study the energy transformation practical systems.
CO7:	Learn the formulations and interrelationships of thermodynamic potentials as well as to use in analyzing various processes in thermodynamic systems.
CO8:	Learn the derivation and physical significance of Maxwell's thermodynamic relations and to apply in solving problems involving change thermodynamic potentials
CO9:	Develop skills in conducting and analyzing experiments related to thermodynamic properties such as temperature, pressure, and volume.
CO10:	Gain experience in interpreting experimental data and documenting findings in structured lab reports with enhanced clarity while fostering teamwork in the laboratory work.

3.0 SKILLS TO BE LEARNED

- To solve complex thermodynamic problems using appropriate equations and methods.
- Apply thermodynamic principles to engines, refrigerators, and chemical reactions.
- Determine and analyze thermodynamic properties experimentally.

4.0 DETAILED CONTENTS OF THE COURSE: THEORY

Credit: 3 **Classroom Teaching: 45 Horus**

MODULE 1

Kinetic Theory of Gases: Maxwell-Boltzmann Law of Distribution of Velocities in an Ideal Gas and its Experimental Verification. Doppler Broadening of Spectral Lines and Stern's Experiment. Mean, RMS and Most Probable Speeds. Degrees of Freedom. Law of Equipartition of Energy (No proof required). Specific heats of Gases. **(3 Lectures)**

Molecular Collisions: Mean Free Path. Collision Probability. Estimates of Mean Free Path. Transport Phenomenon in Ideal Gases: (1) Viscosity, (2) Thermal Conductivity and (3) Diffusion. Brownian Motion and its Significance. **(4 Lectures)**

Real Gasses: Deviations from the Ideal Gas Equation. The Virial Equation. Andrew's Experiments on CO_2 Gas. Critical Constants. Continuity of Liquid and Gaseous State. Vapour and Gas. Boyle Temperature. Van der Waals Equation of State for Real Gases. Values of Critical Constants. Law of Corresponding States. Comparison with Experimental Curves. p-V Diagrams. Joule's Experiment. Free Adiabatic Expansion of a Perfect Gas. Joule-Thomson Porous Plug Experiment. Joule Thomson Effect for Real and Van der Waal Gases. Temperature of Inversion. Joule Thomson Cooling **[8 Lectures]**

MODULE 2

Zeroth and First Law of Thermodynamics: Extensive and intensive Thermodynamic Variables, Thermodynamic Equilibrium, Zeroth Law of Thermodynamics & Concept of Temperature, Concept of Work & Heat, State Functions, First Law of Thermodynamics and its differential form, Internal Energy, First Law & various processes, Applications of First Law: General Relation between C_P and C_V, Work Done during Isothermal and Adiabatic Processes, Compressibility and Expansion Coefficient. **[6 Lectures]**

Second Law of Thermodynamics: Reversible and Irreversible process with examples. Conversion of Work into Heat and Heat into Work. Heat Engines. Carnot's Cycle, Carnot engine & efficiency. Refrigerator & coefficient of performance, 2nd Law of Thermodynamics: Kelvin-Planck and Clausius Statements and their Equivalence. Carnot's Theorem. Applications of Second Law of Thermodynamics: Thermodynamic Scale of Temperature and its Equivalence to Perfect Gas Scale. **[6 Lectures]**

MODULE 3

Entropy: Concept of Entropy, Clausius Theorem. Clausius Inequality, Second Law of Thermodynamics in terms of Entropy. Entropy of a perfect gas. Principle of Increase of Entropy. Entropy Changes in Reversible and Irreversible processes with examples. Entropy of the Universe. Entropy Changes in Reversible and Irreversible Processes. Principle of Increase of Entropy. Temperature–Entropy diagrams for Carnot's Cycle. Third Law of Thermodynamics. Unattainability of Absolute Zero [**4 Lectures]**

Thermodynamic Potentials: Extensive and Intensive Thermodynamic Variables. Thermodynamic Potentials: Internal Energy, Enthalpy, Helmholtz Free Energy, Gibbs Free Energy. Their Definitions, Properties and Applications. Surface Films and Variation of Surface Tension with Temperature. Magnetic Work, Cooling due to adiabatic demagnetization, First and second order Phase Transitions with examples, Clausius Clapeyron Equation and Ehrenfest equations [**5 Lectures]**

Derivations and applications of Maxwell's Relations: Maxwell's Relations:(1) Clausius Clapeyron equation, (2) Values of Cp-Cv, 21 (3) Tds Equations, (4) Joule-Kelvin coefficient for Ideal and Van der Waal Gases, (5) Energy equations, (6) Change of Temperature during Adiabatic Process. **[6 Lectures]**

5.0 DETAILED CONTENTS OF THE COURSE: PRACTICUM

Credit: 1 **Laboratory Work: 30 Hours**

In practicum, students perform a variety of experiments designed to illustrate and reinforce theoretical concepts of heat and thermodynamics. Students are required to conduct experiments from the provided list, meticulously following the suggested procedures and protocols outlined for each. Subsequently, they must compile comprehensive reports for every experiment, adhering to scientific standards and conventions. These reports should encompass a detailed description of the experimental setup and methodology employed, including any modifications made during the course of the experiment. Furthermore, students are expected to record and analyze their experimental data systematically, drawing upon relevant theoretical concepts and principles to interpret their findings accurately. Additionally, the reports should include a thorough discussion of the results obtained, highlighting any observed trends, anomalies, or correlations, and offering insightful explanations or hypotheses where applicable. Moreover, students must demonstrate proficiency in presenting their results graphically, utilizing tables, figures, and diagrams to enhance clarity and facilitate comprehension. Finally, each report should conclude with a succinct summary of the key findings and conclusions drawn from the experiment, along with any recommendations for further investigation or improvement.

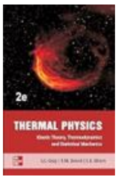
The teacher has the flexibility to introduce a wide range of laboratory experiments that directly correlate with and reinforce the theoretical concepts covered in the course curriculum. These experiments serve as practical applications of the theoretical principles discussed in lectures.

Suggested List of Experiment:

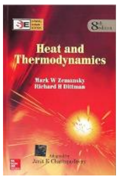
1. To determine the pressure coefficient of air by constant volume air thermometer.
2. To determine the melting point of a substance with a constant volume air thermometer.
3. To determine the specific heat of a liquid by the method of cooling
4. To determine the specific heat of copper-by-copper block calorimeter
5. To determine the coefficient of thermal conductivity of copper by Searle's apparatus.
6. To determine the coefficient of thermal conductivity of a rubber tubing.
7. To determine the coefficient of thermal conductivity of a glass in the form of a tube.
8. To determine the conductivity of glass by the method of Lees and Chorlton.
9. To determine the value of Searle's Fraction Cone method.
10. To determine the mechanical equivalent of heat with Callender and Barnes Continuous flow calorimeter.
11. To determine the temperature coefficient of resistance for platinum by means of Carey Foster's bridge.
12. To determine the temperature coefficient of resistance of platinum by means Callender and Griffth's Bridge.
13. To determine the value of Stefan's Constant.
14. To determine Mechanical Equivalent of Heat, J, by Callender and Barnes constant flow method.
15. To determine the Coefficient of Thermal Conductivity of Cu by Searle's Apparatus.
16. To determine the Coefficient of Thermal Conductivity of Cu by Angstrom's Method.

17. To determine the Coefficient of Thermal Conductivity of a bad conductor by Lee and Charlton's disc method.
18. To determine the Temperature Coefficient of Resistance by Platinum Resistance Thermometer (PRT).
19. To study the variation of Thermo-Emf of a Thermocouple with Difference of Temperature of its Two Junctions.
20. To calibrate a thermocouple to measure temperature in a specified Range using Null Method as well as Direct measurement and to determine Neutral Temperature.

6.0 TEXT BOOKS

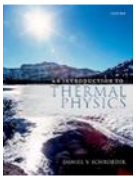


Name: Thermal Physics: with Kinetic Theory, Thermodynamics and Statistical Mechanic
Author: S.C. Garg, R.M. Bansal and C.K. Ghosh
Edition: 2nd Ed.
Publisher: McGraw Hill Education
ISBN: 978-1259003356

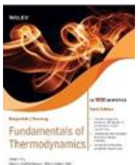


Name: Heat and Thermodynamics
Author: Mark Zemansky and Richard Dittman
Edition: 8th Ed
Publisher: McGraw Hill Education
ISBN: 978-0070700352

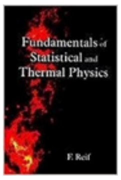
7.0 REFERENCE BOOKS AND MATERIALS



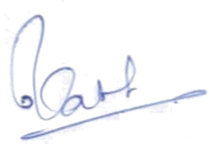
Name: An Introduction to Thermal Physics
Author: Daniel V. Schroeder
Edition: 2021
Publisher: Oxford
ISBN: 978-0192895547

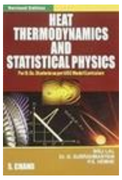


Name: Fundamentals of Thermodynamics
Author: Claus Borgnakke ; Richard E. Sonntag; Souvik Bhattacharyya; Manoj Kumar Soni
Edition:10th Ed.
Publisher: Wiley
ISBN: 978-9354642210

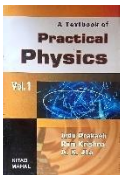


Name: Fundamentals of Statistical and Thermal Physics
Author: E Reif
Edition:
Publisher: Sarat Book House
ISBN: 978-9380663142

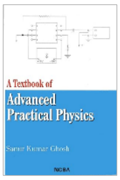




Name: Heat Thermodynamics & Statistical Physics
Author: Brijlal and Subrahmanyam
Edition: 2017
Publisher: S.Chand
ISBN: 978-8121928137



Name: A textbook of Practial Physics
Author: Indu Prakash, Rama Krishna, A.K. Jha
Edition: 2011
Publisher: Kitab Mahal
ISBN: 978-8122504163



Name: A Textbook of Advanced Practical Physics
Author: Samir Kumar Ghosh
Edition: 2008
Publisher: New Central Book Agency
ISBN: 978-8173812439

86.0 MAPPING OF CLO TO PO AND PSO

The course outcomes and their mapping with program outcomes are specified in the table below

Course Learning Outcomes	Programme Outcomes (POs)												Programme Specific Outcome (PSOs)					
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6
CO1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

9.0 ASSESSMENT SCHEME

The evaluation system for this course consists of an 80% weightage on a comprehensive theory examination, which assesses students' understanding of various course topics, and a 20% weightage allocated to internal assessments, including internal examinations, assignments, class participation, and overall engagement in the course throughout the semester.

THEORY:

(A) Internal assessment: (20 marks): Continuous evaluation and internal assessment are implemented to foster and maintain a thorough understanding throughout the learning process. By regularly assessing

comprehension through assignments, quizzes, and class participation, educators can address learning gaps promptly and support students in achieving deeper knowledge and proficiency in the subject matter.

(B) End-term examination (80 marks): The end-term examination serves as a culmination of students' learning in the course, assessing their comprehensive understanding and proficiency in various topics in the course. It provides a structured platform for students to demonstrate their knowledge, problem-solving abilities, and application of theoretical concepts, ultimately gauging their readiness to progress. Pattern of End term question paper

Section	Total Questions	Marks for each question	have to attempt	Total Marks
A	5	4	4	20
B	5	10	3	30
C	4	15	2	30

PRACTICUM:

(A) Internal assessment: (20 marks): In the internal assessment of the practicum components, the student's performance, understanding, skills, sincerity, and involvement in laboratory work during the entire semester are evaluated.

(B) End-term examination (80 marks): The ability to apply theoretical knowledge to real-world situations is the fundamental criterion used in the End Term examination. It typically involves students' activity on randomly assigned laboratory works and the Laboratory Report (Notebook) on the performed work in the entire semester. In the End examination, the student must complete randomly assigned tasks and prepare a report on their work, including appropriate conclusions. The mark distribution for the End term examination as follows.

Activity	Marks
Laboratory work in the Examination	40
Laboratory Notebook	20
Presentation/Viva-voce	20

PHY 001 MC 3110: MODERN PHYSICS

NCrF Level:	5.5	
Programme:	Four Year Undergraduate Programme	**Semester:** Fifth
Course Category:	Minor Course	
Credit (L: T: P)	3: 0: 1	
Credit Hours	Theory: 45 Hours, Practical 30 Hours	

1.0 COURSE LEARNING OBJECTIVES

This course explores key concepts and discoveries in modern physics, including relativity, quantum mechanics, atomic structure, nuclear physics, and elementary particles. It emphasizes both theoretical understanding and practical applications. The Learning Objectives of the course are:

- Grasp the principles and consequences of special relativity on time, space, and energy.
- Apply fundamental concepts to analyze and solve problems in atomic and subatomic systems.
- Describe the structure, behaviour, and interactions of atoms and nuclei.

2.0 COURSE LEARNING OUTCOME

After completing this course, students will be able to,

CO	Outcomes
CO1:	Understand and apply the principles of special relativity to analyze the effects of relative motion on time, length, and mass, and solve problems involving relativistic dynamics.
CO2:	Learn historical progression of atomic theory, the discovery and characterization of the electron, and the role of positive rays in understanding atomic structure.
CO3:	Understand and apply the vector atom model to describe atomic structure, including the quantization of angular momentum and the coupling of electron spins and orbital motions.
CO4:	Learn the historical development of quantum theory, wave-particle duality, concept of wave function, Schrödinger equation and their use in practical problems.
CO5:	Get a basic understanding on nuclear structure, properties, and interactions, including the principles of nuclear stability, radioactive decay processes, and nuclear reactions.
CO6:	Learn principles of elementary particle classification, interactions and the quark model along with mechanisms behind the particle accelerators and detectors.
CO7:	Learn to apply theoretical concepts to design and execute experiments, analyze data, and draw meaningful conclusions about the properties and behaviours of atoms.
CO8:	Able to prepare clear, structured, and concise scientific reports, effectively presenting laboratory works and findings with enhanced clarity.

3.0 SKILLS TO BE LEARNED

- to think critically and solve complex problems using advanced mathematical and conceptual frameworks, particularly in understanding quantum mechanics, relativity, and particle physics.
- designing and conducting experiments, using modern scientific instruments, and analyzing experimental data, which are crucial for research in cutting-edge physics.
- To explain various phenomena governing the universe at both the subatomic and cosmological levels, and to apply and predict physical behaviour in a wide range of contexts.

4.0 DETAILED CONTENTS OF THE COURSE: THEORY

Credit: 3 **Classroom Teaching: 45 Horus**

MODULE 1

Special Theory of Relativity: Galilean Transformation Equations, Ether Hypothesis, Michelson-Morley experiment, Lorentz transformation equations, Length Contraction, time dilation, relativity of simultaneity, variation of mas with velocity, Mass energy equivalence. **[5 hours]**

Electron and Positive Rays: Millikan oil-drop experiment - determination of e/m , Positive Rays - Thomson's Parabola Method, Mass Spectrograph **[4 hours]**

Atomic Structure: Rutherfor's experiments, Bohr's atomic model and its limitations, Frank Hertz Experiment, Sommerfeld's modification of Bohr's Theory, **[6 hours]**

MODULE 2

Vector Atom Model: quantum numbers associated with vector atom model,Orbital angular momentum and spin angular momentum, Space quantization. Orbital Magnetic moment, Larmor's Theorem, Spin Magnetic Moment. Stern- Gerlach Experiment, Gyromagnetic Ratio, spin orbit interaction, Atoms in external Magnetic fields - Normal and Anomalous Zeeman Effect, Paschen-Back and Stark Effect (Qualitative Discussion only). **[7 hours]**

Quantum Theory: Failure of classical physics, Black body radiation; Photoelectric effect; Compton effect. de Broglie waves, Matter waves, Wave packets, Uncertainty principle. Wave function, Schrodinger's equations, application of Schrodinger equation - potential well and potential barrier **[8 hours]**

MODULE 3

The Nucleus : General properties of the Nucleus BindingBidding energy curve, nuclear Stability, liquid drop model, -semi empirical mass formula, shell model (brief idea only) - magic numbers. Radioactive Decay - alpha, beta and gamma rays, Decay laws and half-life, applications of radioactivity **[7 hours]**

Particle Physics: fundamental interactions, classification of elementary particle, antiparticle, the quark model - standard model, Particle detectors **-** Ionization chamber, proportional counter, GM counter, Wilson Cloud chamber, Particle accelerators - linear accelerator, Cyclotron, Betaton **[6 hours]**

Cosmic Rays and Nuclear Reaction: Origin of Cosmic Rays - primary and Secondary Cosmic Rays, Latitude Effect, and East-west Effect; Nuclear Fission-chain Reaction, Nuclear Reactors, Nuclear Fusion. **[3 hours]**

5.0 DETAILED CONTENTS OF THE COURSE: PRACTICUM

Credit: 2 **Laboratory Work: 60 Hours**

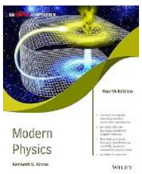
In the practicum component of the course, students will undergo a number of experiments related to different phenomena of modern physics. Students are required to conduct experiments from the provided list, meticulously following the suggested procedures and protocols outlined for each. Subsequently, they must compile comprehensive reports for every experiment, adhering to scientific standards and conventions. These reports should encompass a detailed description of the experimental setup and methodology employed, including any modifications made during the course of the experiment. Furthermore, students are expected to record and analyze their experimental data systematically, drawing upon relevant theoretical concepts and principles to interpret their findings accurately. Additionally, the reports should include a thorough discussion of the results obtained, highlighting any observed trends, anomalies, or correlations, and offering insightful explanations or hypotheses where applicable. Moreover, students must demonstrate proficiency in presenting their results graphically, utilizing tables, figures, and diagrams to enhance clarity and facilitate comprehension. Finally, each report should conclude with a succinct summary of the key findings and conclusions drawn from the experiment, along with any recommendations for further investigation or improvement.

The teacher has the flexibility to introduce a wide range of laboratory experiments that directly correlate with and reinforce the theoretical concepts covered in the course curriculum. These experiments serve as practical applications of the theoretical principles discussed in lectures.

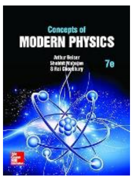
Suggestive List of experiments:

1. To study the quantized energy levels in atoms by measuring the energy exchange between electrons and mercury atoms using Franck-Hertz experiment.
2. To determine the elementary electric charge by observing the motion of charged oil droplets in an electric field through Millikan Oil Drop Experiment.
3. To study the emission of electrons from a metal surface when light of varying frequencies is incident upon it, confirming the quantized nature of light. (Photoelectric effect)
4. To study the splitting of spectral lines in the presence of a magnetic field, providing evidence for the quantization of angular momentum. (Zeeman Effect exit)
5. Measurement of Planck's constant using black body radiation and photo-detector.
6. To determine the work function of material of filament of directly heated vacuum diode.
7. To determine the wavelength of the H-alpha emission line of Hydrogen atoms.
8. To determine the absorption lines in the rotational spectrum of Iodine vapour.
9. To determine the value of e/m by (a) Magnetic focusing or (b) Bar magnet
10. To observe and analyze the electron spin resonance of a paramagnetic sample.
11. To study the nuclear magnetic resonance of a sample containing nuclei with spin quantum numbers.
12. To study the spectral lines emitted or absorbed by atoms and to determine the energy levels and transitions within the atomic structure.
13. Observing the characteristic yellow emission line of sodium atoms when heated in a flame, used for qualitative analysis of sodium compounds.
14. Using a flame to vaporize and atomize a sample, then measuring the intensity of light emitted by specific atomic transitions to quantify the concentration of certain elements.
15. Exciting atoms in a sample with high-voltage sparks and analyzing the resulting emission spectrum to identify elements and study their energy levels.
16. Using an electric arc to vaporize and excite atoms in a sample, then analyzing the emission spectrum to identify elements and study their properties.

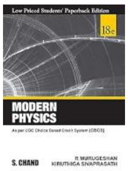
6.0 TEXT BOOKS



Name: Modern Physics
Author: Kenneth S. Krane
Edition: 4th Ed.
Publisher: Wiley
ISBN: 978-9354244681

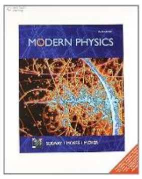


Name: Concepts of Modern Physics
Author: Arthur Beiser, Shobhit Mahajan, S. Rai Choudhury
Edition: 7th Ed. (2017)
Publisher: McGraw Hill Education
ISBN: 978-9351341857

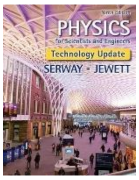


Name: Modern Physics
Author: R Murugeshan, Kiruthiga Sivaprasath
Edition: 18th Ed. (2017)
Publisher: S Chand Publishing
ISBN: 978-9352533107

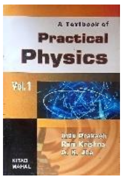
7.0 REFERENCE BOOKS AND MATERIALS



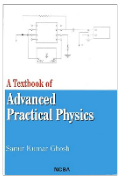
Name: Modern Physics
Author: Raymond A. Serway
Edition: 3rd Ed.
Publisher: Cengage
ISBN: 978-8131517482



Name: Physics for scientists and Engineers with Modern Physics
Author: J.W. Jewett, R.A. Serway,
Edition: 9th Ed.
Publisher: Brooks/Cole
ISBN: 978-1305116399



Name: A textbook of Practial Physics
Author: Indu Prakash, Rama Krishna, A.K. Jha
Edition: 2011
Publisher: Kitab Mahal
ISBN: 978-8122504163



Name: A Textbook of Advanced Practical Physics
Author: Samir Kumar Ghosh
Edition: 2008
Publisher: New Central Book Agency
ISBN: 978-8173812439

86.0 MAPPING OF CLO TO PO AND PSO

The course outcomes and their mapping with program outcomes are specified in the table below

Course Learning Outcomes	Programme Outcomes (POs)												Programme Specific Outcome (PSOs)					
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6
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CO2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

9.0 ASSESSMENT SCHEME

The evaluation system for this course consists of an 80% weightage on a comprehensive theory examination, which assesses students' understanding of various course topics, and a 20% weightage allocated to internal assessments, including internal examinations, assignments, class participation, and overall engagement in the course throughout the semester.

THEORY:

(A) Internal assessment: (20 marks): Continuous evaluation and internal assessment are implemented to foster and maintain a thorough understanding throughout the learning process. By regularly assessing comprehension through assignments, quizzes, and class participation, educators can address learning gaps promptly and support students in achieving deeper knowledge and proficiency in the subject matter.

(B) End-term examination (80 marks): The end-term examination serves as a culmination of students' learning in the course, assessing their comprehensive understanding and proficiency in various topics in the course. It provides a structured platform for students to demonstrate their knowledge, problem-solving abilities, and application of theoretical concepts, ultimately gauging their readiness to progress. Pattern of End term question paper

Section	Total Questions	Marks for each question	have to attempt	Total Marks
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PRACTICUM:

(A) Internal assessment: (20 marks): In the internal assessment of the practicum components, the student's performance, understanding, skills, sincerity, and involvement in laboratory work during the entire semester are evaluated.

(B) End-term examination (80 marks): The ability to apply theoretical knowledge to real-world situations is the fundamental criterion used in the End Term examination. It typically involves students' activity on randomly assigned laboratory works and the Laboratory Report (Notebook) on the performed work in the entire semester. In the End examination, the student must complete randomly assigned tasks and prepare a report on their work, including appropriate conclusions. The mark distribution for the End term examination as follows.

Activity	Marks
Laboratory work in the Examination	40
Laboratory Notebook	20
Presentation/Viva-voce	20

PHY 001 MC 3210: SOLID STATE PHYSICS AND ELECTRONICS

NCrF Level: 5.5
Programme: Four Year Undergraduate Programme **Semester:** Sixth
Course Category: Minor Course
Credit (L: T: P) 3: 0: 1
Credit Hours Theory: 45 Hours, Practical 30 Hours

1.0 COURSE LEARNING OBJECTIVES

The course provides a foundational understanding of solid-state physics, covering topics such as crystal structures, electronic band theory, and semiconductor materials. It also introduces fundamental principles of electronics, including digital and analog circuits, enabling students to apply theoretical knowledge to practical circuit design and analysis. The Learning Objectives of the course are:

- Grasp the basics of crystal structures, lattice dynamics, and band theory.
- Understand the principles of semiconductors and semiconductor devices
- Understand the design, analysis, and practical implementation of amplifiers and oscillators.
- Analyze and apply principles of electronic communication systems,
- Utilizing electronic measuring instruments to conduct various experiments.

2.0 COURSE LEARNING OUTCOME

After completing this course, students will be able to,

CO	Outcomes
CO1:	Understand and analyze the arrangement of atoms in crystalline solids, including their geometric structures, symmetry properties, and the implications on material properties.
CO2:	Learn the principles of electronic band structures, including the formation of energy bands, band gaps, and their effects on the electrical, thermal, and optical properties of materials.
CO3:	Understand the operating principles and characteristics of semiconductor diodes, and will be able to analyze and design basic diode circuits for various practical applications.
CO4:	Understand the operation different types of transistors and their use in the design of amplifier and oscillator circuits.
CO5:	Understand the principles and applications of digital logic, including the design, analysis, and implementation of combinational and sequential circuits.
CO6:	Learn the basics of Analog communication systems and techniques of signal transmission, reception in the modern world.
CO7:	Gain hands-on experience in building and testing electronic circuits using different instruments and develop technical competence to troubleshoot electronic circuits.
CO8:	Able to prepare clear, structured, and concise scientific reports, effectively presenting laboratory works and findings with enhanced clarity.

3.0 SKILLS TO BE LEARNED

- To analyze the properties of materials by exploring the band formation in solids.
- Design, develop and build analog circuits such as amplifiers, oscillators, and filters.
- Use of different electronic measuring instruments to measure various electronic parameters.
- diagnosing and fixing issues in electronic circuits using tools like oscilloscopes and multimeters.

4.0 DETAILED CONTENTS OF THE COURSE: THEORY

Credit: 3 **Classroom Teaching: 45 Hours**

MODULE 1

Crystal Structure: Introduction, Crystal lattice and translation vectors, unit cell, Basis, Symmetry operations, point groups and space groups, types of lattices (Plane lattice and Space lattice with bcc and fcc), Lattice directions and planes, Miller indices, simple Crystal structure. **[3 hours]**

Band Theory of Solids: Introduction, Concept of interatomic forces, Cohesive energy and types of bonding, Primary bonds (ionic bonds, Covalent bond and metallic bond), secondary bonds (Van Der wails bond and hydrogen bonds) The Bloch theorem (only statement and properties), The Kroning Perry model, Energy versus Wave Vector relationship --- different representations (Brillouin Zones). **[7 hours]**

MODULE 2

DC circuits: Network elements - active and passive, Voltage divider and current divider theorem. Series and parallel combination of resistor, capacitor and inductor, circuit analysis techniques, superposition principle, Thevenin theorem, Norton theorem and their applications. **[5 Lectures]**

Semiconductor Physics and Junction diode: Intrinsic and extrinsic semiconductor, Drift and diffusion of carriers, mobility and conductivity, P-type and N-type semiconductor, Hall effect barrier formation in PN Junction Diode, Current Flow Mechanism, Static and Dynamic Resistance, Diode as Rectifier: Half-wave, full wave Rectifiers, Ripple Factor and Rectification Efficiency, Zener Diode and Voltage Regulation, photodiode - solar cell. **[7 Lectures]**

Transistor: Bipolar Junction Transistor (n-p-n and p-n-p) - Characteristics of Configurations. Current gains α and β Relations between α and β, application of transistor as switch and amplifiers, Basic of FET and MOSFET **[3 Lectures]**

MODULE 3

Amplifier and Oscillator: Single stage and multistage transistor amplifier, characteristics of amplifiers - gain, input and output impedance, band width, RC coupled amplifiers and its frequency response, Feedback in amplifiers , Oscillators - Barkhuizen Criterion, Phase shift oscillator **[5 Lectures]**

Digital Circuits: decimal, binary, octal and hexadecimal number systems; conversion from one number system to another, BCD code, Logic gates - AND, OR and NOT Gates, Boolean algebra, De Morgan's Theorems, Simplification of Logic Circuit using Boolean Algebra. K -map, Encoder, Decoder, half adder, full adder, **[8 Lectures]**

Electronic Communications: Analog communication system, Amplitude modulation (AM), Frequency modulation (FM) and phase modulation, AM and FM transmitters and receivers, [**2 hours]**

5.0 DETAILED CONTENTS OF THE COURSE: PRACTICUM

Credit: 1 **Laboratory Work: 30 Hours**

In the practicum component of the course, students will undergo a number of experiments related to electronics and various phenomena of solid-state physics.

Students are required to conduct experiments from the provided list, meticulously following the suggested procedures and protocols outlined for each. Subsequently, they must compile comprehensive reports for every experiment, adhering to scientific standards and conventions. These reports should encompass a detailed description of the experimental setup and methodology employed, including any modifications made during the course of the experiment. Furthermore, students are expected to record and analyze their experimental data systematically, drawing upon relevant theoretical concepts and principles to interpret their findings accurately. Additionally, the reports should include a thorough discussion of the results obtained, highlighting any observed trends, anomalies, or correlations, and offering insightful explanations or hypotheses where applicable. Moreover, students must demonstrate proficiency in presenting their results graphically, utilizing tables, figures, and diagrams to enhance clarity and facilitate comprehension. Finally, each report should conclude with a succinct summary of the key findings and conclusions drawn from the experiment, along with any recommendations for further investigation or improvement.

The teacher has the flexibility to introduce a wide range of laboratory experiments that directly correlate with and reinforce the theoretical concepts covered in the course curriculum. These experiments serve as practical applications of the theoretical principles discussed in lectures.

Laboratory skill:

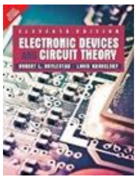
1) Identification of electronic components and measurement of their ratings.
2) Use of breadboard and hook-up wire in a laboratory experiment.
3) Design of circuit in Breadboard and hook up wire.
4) Use of multimeter and LCR meter for measuring resistance, voltage, current etc.
5) Use of Oscilloscope for the analysis of an AC signal
6) Testing of resistance, inductor, capacitor, diode, transistor etc.
7) Soldering of electronic components
8) Printed circuit board soldering
9) Testing of AND, OR, NOT, XOR, XNOR using NAND and NOR gates in digital IC.

Suggested list of Experiments:

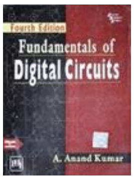
1) Verification of ohm's law, Kirchhoff's Voltage Law and Kirchhoff's Current Law
2) Verify voltage divider theorem and current divider theorem with four resistances
3) Verify superposition principle in an electronic circuit with a multi-source.
4) Verify Thevenin's Theorem and Norton's Theorem in electronic circuits.
5) Measure the Hall voltage and determine the type and density of charge carriers in a semiconductor.
6) Measure the electrical resistivity of a material using four probe methods.
7) To draw the characteristic of a silicon diode and a germanium diode under forward bias condition and find cut-in voltage, reverse saturation current, static and dynamic resistances
8) To draw the characteristics of two different Zener diodes & calculate cut-in voltage, reverse Saturation current, break down voltage
9) To draw the static input and output characteristics curves of a transistor in CE configuration and determine its 'h' parameters
10) To draw the static input and output characteristics curves of a transistor in CB configuration and determine its 'h' parameters
11) To compare the Ripple Factor, Efficiency, Peak Factor and regulation characteristics of half wave rectifier, full wave rectifier and Bridge rectifier.
12) Construction of AND, OR, NOT using resistor, diode and transistor.
13) Construction of AND, OR, NOT, XOR, XNOR using NAND and NOR gates.
14) Design and construction of half adder, half subtractor, full adder using Universal gates.

6.0 TEXT BOOKS

Name: Introduction to Solid State Physics
Author: Charles Kittel
Edition: 2019
Publisher: Wiley
ISBN: 978-8126578436



Name: Electronic Devices and Circuit Theory
Author: Robert L. Boylestad and Louis Nashelsky
Edition: 11^{th} Ed.
Publisher: Pearson Education India
ISBN: 978-9332542600

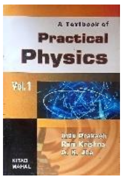


Name: Fundamentals of Digital Circuits
Author: A. Anand Kumar
Edition: 4^{th} Ed.
Publisher: PHI Learning Pvt. Ltd.
ISBN: 978-8120352681

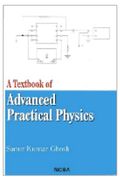
7.0 REFERENCE BOOKS AND MATERIALS

Name: Solid State Physics
Author: Neil W. Ashcroft and N. David Mermin
Edition: 1^{st} Ed.
Publisher: Cengage
ISBN: 978-8131500521

Name: Principles of Electronics
Authors: V.K. Mehta and Rohit Mehta
Edition: 12^{th} Ed.
Publisher: S. Chand Publishing
ISBN: 978-9352838363



Name: A textbook of Practial Physics
Author: Indu Prakash, Rama Krishna, A.K. Jha
Edition: 2011
Publisher: Kitab Mahal
ISBN: 978-8122504163



Name: A Textbook of Advanced Practical Physics
Author: Samir Kumar Ghosh
Edition: 2008
Publisher: New Central Book Agency
ISBN: 978-8173812439

8.0 MAPPING OF CLO TO PO AND PSO

The course outcomes and their mapping with program outcomes are specified in the table below

Course Learning Outcomes	Programme Outcomes (POs)												Programme Specific Outcome (PSOs)					
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6
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CO2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

9.0 ASSESSMENT SCHEME

The evaluation system for this course consists of an 80% weightage on a comprehensive theory examination, which assesses students' understanding of various course topics, and a 20% weightage allocated to internal assessments, including internal examinations, assignments, class participation, and overall engagement in the course throughout the semester.

THEORY:

(A) Internal assessment: (20 marks): Continuous evaluation and internal assessment are implemented to foster and maintain a thorough understanding throughout the learning process. By regularly assessing comprehension through assignments, quizzes, and class participation, educators can address learning gaps promptly and support students in achieving deeper knowledge and proficiency in the subject matter.

(B) End-term examination (80 marks): The end-term examination serves as a culmination of students' learning in the course, assessing their comprehensive understanding and proficiency in various topics in the course. It provides a structured platform for students to demonstrate their knowledge, problem-solving abilities, and application of theoretical concepts, ultimately gauging their readiness to progress. Pattern of End term question paper

Section	Total Questions	Marks for each question	have to attempt	Total Marks
A	5	4	4	20
B	5	10	3	30
C	4	15	2	30

PRACTICUM:

(A) Internal assessment: (20 marks): In the internal assessment of the practicum components, the student's performance, understanding, skills, sincerity, and involvement in laboratory work during the entire semester are evaluated.

(B) End-term examination (80 marks): The ability to apply theoretical knowledge to real-world situations is the fundamental criterion used in the End Term examination. It typically involves students' activity on randomly assigned laboratory works and the Laboratory Report (Notebook) on the performed work in the entire semester. In the End examination, the student must complete randomly assigned tasks and prepare a report on their work, including appropriate conclusions. The mark distribution for the End term examination as follows.

Activity	Marks
Laboratory work in the Examination	40
Laboratory Notebook	20
Presentation/Viva-voce	20

MULTI-DISCIPLINARY COURESES

PHY-001- CC 1110: PHYSICS FOR EVERYONE

NCrF Level:	4.5	
Programme:	Four-Year Undergraduate Programme	**Semester:** First
Course Category:	Multi-disciplinary Course (MDC)	
Credit (L: T: P)	3: 0: 0	
Credit Hours	Theory: 45 Hours	

1.0 COURSE LEARNING OBJECTIVES

The aim of the course is to provide fundamental knowledge of diverse phenomena of physics and their practical applications to the students coming from non-scientific backgrounds. Enrichment of scientific knowledge related to various physical phenomena is an additional objective of the present course. The Learning Objectives of the course are:

- Understand and explain basic principles of physics, including mechanics, electromagnetism, thermodynamics, and optics, and how they relate to everyday phenomena.
- Develop skills in scientific inquiry, including formulating hypotheses, designing experiments, collecting and analyzing data, and drawing evidence-based conclusions.
- Apply physics concepts to solve real-world problems and understand the role of physics in technology, the environment, and everyday life.
- Enhance critical thinking and problem-solving abilities by engaging with a variety of physics problems and scenarios, fostering a deeper appreciation for the scientific method and logical reasoning.

2.0 COURSE LEARNING OUTCOME

After completing this course, students will be able to,

CO	Outcomes
CO1:	Learn a comprehensive understanding of how physics has evolved as a scientific discipline, its impact on society and technology, and the broader implications of its historical development.
CO2:	Get a thorough understanding of measurement systems, preparing them to effectively apply measurement techniques to different fields of study or profession.
CO3:	A comprehensive understanding of the fundamental principles of motion, work, energy, and power in physics to enable them to deal with various practical problems in everyday life.
CO4:	Understanding the fundamental principles of rotational motion and gravitation can provide valuable insights into various phenomena encountered in daily life.
CO5:	Understand the fundamental principles governing wave behaviour, optical phenomena, and their diverse applications across scientific disciplines and technological innovations.
CO6:	understanding of thermodynamic principles, heat transfer mechanisms, and their practical applications in engineering, environmental science, and everyday life.
CO7:	Learn the fundamental principles of magnetic fields and magnetic materials as well as able to explain the principle and applications of electromagnetic induction.
CO8:	Gain a basic idea of propagation characteristics of electromagnetic waves, their interaction with matter, and their applications in communication, imaging, and modern technology.

3.0 SKILLS TO BE LEARNED

- To understand various phenomena in every day life though the concept of physics
- To measure and calculate different physical quantities
- To identify the types of motion observed in real world.
- To identify the nature of wave generated in real world and analysis their characteristics
- To explain various events observed in daily life through the concept of physics.

4.0 DETAILED CONTENTS OF THE COURSE: THEORY

Credit: 3 **Classroom Teaching:** 45 Hours

MODULE 1

Physics and its Historical development: What are physics and its importance in our life, The historical, philosophical, and practical evolution of Physics from its roots in ancient natural philosophy. Preliterate origins, Ancient Egypt and Mesopotamia, modern science after 15^{th} centuries. A golden age of physics. Modern Physics, various branched of physics **[5 hours]**

Measurement system: Measurement and its importance in physics, History of unit and measurement systems, international system of units, significant figures and rounding off in measurement, rules for arithmetic operation with significant digits. **[5 hours]**

Observation and experimentation in Physics: Steps of scientific study of natural behaviour of objects, observation, design of experiment, experimental data collection, analysis of experimental data: drawing curve, formation of equation, development of phenomena, Importance of curve and equation in physics. Theocratical physics and experimental physics, importance of experimentation. **[5 hours]**

MODULE 2

Motion of object: Scaler and vector quantities with examples, displacement, speed and velocity, acceleration, momentum, Newton's laws of motion and its applications. **[5 hours]**

Work, Energy and Power: Work done, Kinetic energy and potential energy, power **[2 hours]**

Rotational Motion: Rigid body under rotation, rotational axis, centre of mass, angular velocity, angular acceleration, Torque, center of gravity, idea about moment of inertia and its applications. **[3 hours]**

Gravitation: Kepler's laws, Universal Law of Gravitation: Gravitational constant, acceleration due to gravity, variation of acceleration due to gravity on earth (above and below earth surface), Escape speed, Artificial Satellites- geosynchronous satellites. **[5 hours]**

MODULE 3

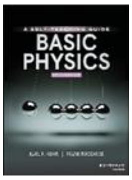
Waves and Optics: Oscillatory motion, waves – frequency and wavelength, transverse and longitudinal wave, sound wave, historical development of light – corpuscular theory to electromagnetic wave, curved mirrors and lens – telescope and microscope, interference, diffraction and polarization of light, **[3 hours]**

Thermal Physics: Heat and temperature – measurement techniques, heat transfer: conduction, convection and radiation, Newton's laws of cooling, fundamental ideas about heat engines**. [5 hours]**

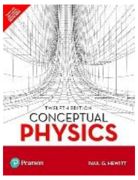
Magnetism: Properties of magnets, lines of forces and flux, magnetic needle, earth's magnetic field, artificial magnet, electromagnetic induction: Lenz's law, AC generator **[4 hours]**

Electromagnetic waves: Nature of electromagnetic waves, electromagnetic spectrum, radio waves, microwave, infra-red waves, visible rays, UV-rays, X-rays and gamma rays and their applications. **[3 hours]**

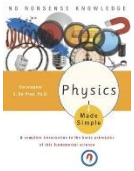
6.0 TEXT BOOKS



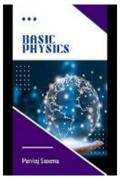
Name: Basic Physics: A Self-Teaching Guide
Author: Karl F. Kuhn and Frank Noschese
Edition: 3rd Ed.
Publisher: Jossey-Bass
ISBN: 978-1119629900



Name: Conceptual Physics
Author: Paul G. Hewitt
Edition: 12th Ed.
Publisher: Pearson Education
ISBN: 978-9352861774

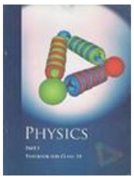


Name: Physics Made Simple: A Complete Introduction to the Basic Principles of This Fundamental Science
Author: Christopher G. De Pree
Edition: 2nd Ed.
Publisher: Crown
ISBN: 978-0767917018

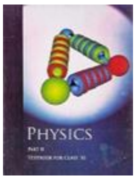


Name: BASIC PHYSICS
Author: Pankaj Saxena
Edition: 2023
Publisher: Notion Press
ISBN: 979-8891332300

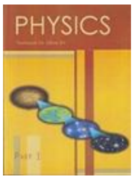
7.0 REFERENCE BOOKS AND MATERIALS



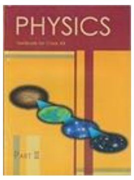
Name: Physics Textbook P For Class - 11
Author: NCERT
Edition: 2023
Publisher: National Council of Education Research and Training
ISBN: 978-8174505088



Name: Physics Textbook Part - 1 For Class - 11
Author: NCERT
Edition: 2023
Publisher: National Council of Education Research and Training
ISBN: 978-8174505668



Name: Physics Textbook Part - 1 For Class - 12
Author: NCERT
Edition: 2023
Publisher: National Council of Education Research and Training
ISBN: 978-8174506313



Name: Physics Textbook Part - 2 For Class - 12
Author: NCERT
Edition: 2023
Publisher: National Council of Education Research and Training
ISBN: 978-8174506719

8.0 MAPPING OF CLO TO PO AND PSO

The course outcomes and their mapping with program outcomes are specified in the table below

Course Learning Outcomes	Programme Outcomes (POs)												Programme Specific Outcome (PSOs)					
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6
CO1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

9.0 ASSESSMENT SCHEME

The evaluation system for this course consists of an 80% weightage on a comprehensive theory examination, which assesses students' understanding of various course topics, and a 20% weightage allocated to internal assessments, including internal examinations, assignments, class participation, and overall engagement in the course throughout the semester.

THEORY:

(A) Internal assessment: (20 marks): Continuous evaluation and internal assessment are implemented to foster and maintain a thorough understanding throughout the learning process. By regularly assessing comprehension through assignments, quizzes, and class participation, educators can address learning gaps promptly and support students in achieving deeper knowledge and proficiency in the subject matter.

(B) End-term examination (80 marks): The end-term examination serves as a culmination of students' learning in the course, assessing their comprehensive understanding and proficiency in various topics in the course. It provides a structured platform for students to demonstrate their knowledge, problem-solving abilities, and application of theoretical concepts, ultimately gauging their readiness to progress. Pattern of End term question paper

Section	Total Questions	Marks for each question	have to attempt	Total Marks
A	5	4	4	20
B	5	10	3	30
C	4	15	2	30

PHY-001-MD-1210: ELECTRONIC AT A GLANCE

NCrF Level:	4.5	
Programme:	Four-Year Undergraduate Programme	**Semester:** Second
Course Category:	Multi-disciplinary Course (MDC)	
Credit (L: T: P)	3: 0: 0	
Credit Hours	Theory: 45 Hours	

1.0 COURSE LEARNING OBJECTIVES

The present course aims to deliver essential knowledge about electricity and electronic components encountered in our day-to-day life to the students coming from non-scientific backgrounds. The Learning Objectives of the course are:

- Acquire fundamental knowledge of electricity and its generation techniques.
- Working principle and phenomena behind the electrical components.
- Achieve preliminary idea about the electronic communication systems used in our daily life

2.0 COURSE LEARNING OUTCOME

After completing this course, students will be able to,

CO	Outcomes
CO1:	Gain a foundational understanding of electricity generation, direct current (DC), alternating current (AC), and the governing laws in electronic circuits.
CO2:	Gain knowledge about various types of batteries and explore techniques used for generating alternating current (AC), including generators and inverters.
CO3:	Gain knowledge about the function, applications, relevance, and underlying physics of various electronic components commonly used in everyday life.
CO4:	Understand the purpose and relevance of different types of semiconductor devices and significance in modern electronic systems.
CO5:	Learn the basics of communication systems, including principles of modulation techniques and their applications in transmitting and receiving signals effectively.

3.0 SKILLS TO BE LEARNED

- Skills to distinguish the types of electrical current and its use
- Skills to understand the various types of battery and electricity generation mechanisms.
- Develop knowledge of different types of electrical components and their use.
- Get an idea about the present communication systems.

4.0 DETAILED CONTENTS OF THE COURSE: THEORY

Credit: 3 **Classroom Teaching:** 45 Hours

MODULE 1

Fundamental of electricity: Electron and electric charge, conductor and insulator, static electricity - generation of static electricity, Electroscopes, current electricity - concept of resistance, ohm's law, direct current and alternating current, pulse, wave, signal and noise, Voltage, Current, Resistance, and Power, electronic measuring instruments – voltmeter, ammeter, Multimeter **[15 hours]**

MODULE 2

Electrical sources: DC sources: Electrical cell (Battery), emf, Internal Resistance, different types of battery and their applications, rechargeable battery, AC sources: electric generator, turbine, hydropower, thermal energy sources, nuclear energy **[10 hours]**

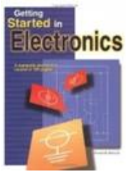
Electronic components: Wire and cables, switches, moving coil meters, microphone and speakers, resistor, capacitors and inductors (coils) **[5 hours]**

MODULE 3

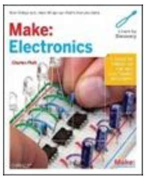
Semiconductor devices: Diode, transistor, FET, MOSFET, Thyristor, SCR, Triacs, optoelectronic components: Light emitting diode, photodiode, phototransistor, photo-thyristors, solar cells. Integrated circuits. Application of diode, transistor, SCR etc. **[10 hours]**

Electronic communications: Block diagram of electronic communication system, modulation, AM and FM, mobile communication **[5 hours]**

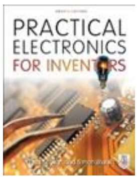
6.0 TEXT BOOKS



Name: Basic Physics: A Self-Teaching Guide
Author: Karl F. Kuhn and Frank Noschese
Edition: 3rd Ed.
Publisher: Jossey-Bass
ISBN: 978-1119629900



Name: Make Electronics – Learning by Discovery
Author: Charles Platt
Edition: 2nd Ed.(2015)
Publisher: Make Community, LLC
ISBN: 978-1680450262

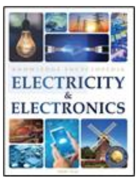


Name: A Text book in Electrical Technology
Author: Paul Scherz, Simon Monk
Edition: 4th Ed.(2016)
Publisher: McGraw Hill TAB
ISBN: 978-1259587542

7.0 REFERENCE BOOKS AND MATERIALS

Name: Make: More Electronics: Journey Deep Into the World of Logic Chips, Amplifiers, Sensors, and Randomicity
Author: Charles Platt
Edition: 1st Ed.(2014)
Publisher: Make Community, LLC
ISBN: 978-1449344047

Name: The Manga Guide to Electricity
Author: D. Ross
Edition: 1st Ed. (2009)
Publisher: No Starch Press
ISBN: 978-1593271978



Name: Electricity and Electronics Science Knowledge Encyclopedia
Author: Wonder House Books
Edition: 2021
Publisher: Wonder House Books
ISBN: 9789354401923

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CO4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
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(A) Internal assessment: (20 marks): Continuous evaluation and internal assessment are implemented to foster and maintain a thorough understanding throughout the learning process. By regularly assessing comprehension through assignments, quizzes, and class participation, educators can address learning gaps promptly and support students in achieving deeper knowledge and proficiency in the subject matter.

(B) End-term examination (80 marks): The end-term examination serves as a culmination of students' learning in the course, assessing their comprehensive understanding and proficiency in various topics in the course. It provides a structured platform for students to demonstrate their knowledge, problem-solving abilities, and application of theoretical concepts, ultimately gauging their readiness to progress. Pattern of End term question paper

Section	Total Questions	Marks for each question	have to attempt	Total Marks
A	5	4	4	20
B	5	10	3	30
C	4	15	2	30

PHY-001-MD 1210: KNOWING OUR UNIVERSE

NCrF Level:	5.0		
Programme:	Four-Year Undergraduate Programme	**Semester:**	Third
Course Category:	Multi-disciplinary Course (MDC)		
Credit (L: T: P)	3: 0: 2		
Credit Hours	Theory: 45 Hours, Practicum: 60 Hours		

1.0 COURSE LEARNING OBJECTIVES

The aim of this course is to enable the students from social science and humanities to give the basic idea about our universe. Edify about the various phenomena observed in the night sky is also an objective of this Course. The Learning objectives of the course are:

- To present the history and the importance of Space Science
- To familiarize with the pioneers of scientifically minded space observers.
- To impart knowledge on the sun, moon and star of universe and their evaluation.
- To review various telescopes used for observation and research

2.0 COURSE LEARNING OUTCOME

After completing this course, students will be able to,

CO	Outcomes
CO1:	Learn about the historical evolution of astronomical observation, prominent astronomers, and the utility of astronomical tools for observation as well as their working principles.
CO2:	Gain a basic understanding of the solar system, including its structure, dynamics, celestial bodies, and their interactions, supported by scientific theories and observational evidence.
CO3:	Learn about the evaluation and classification of stars based on their properties such as temperature, luminosity, size, and evolutionary stage.
CO4:	Get a basic understanding behind the various astronomical events including types, causes, observable phenomena and significance in both historical and modern contexts.
CO5:	Gain knowledge about space exploration efforts and the search for life beyond Earth by human civilization including missions, technologies, scientific methodologies.
CO6:	Get a brief idea about Indian space missions, including their achievements, technological advancements, and contributions to space exploration and applications in various fields.

3.0 SKILLS TO BE LEARNED

- To observe and analyze celestial objects in the night sky.
- To understand the working of various types of telescopes
- To distinguish different astronomical objects: star, galaxy, milky-way etc.
- To apply scientific methods in explaining astronomical phenomena

4.0 DETAILED CONTENTS OF THE COURSE: THEORY

Credit: 3 **Classroom Teaching:** 45 Hours

MODULE 1

The Science of Astronomy: Naked Eye Observations, A Brief History of Space Science, Pioneers of Cosmic observers: Nicolaus Copernicus, Johannes Kepler, Galileo Galilei, Edwin Hubble etc. **[7 hours]**

Tools of Astronomy: History of Telescope, types of telescopes, Reflecting Telescopes, Refracting Telescopes, types of reflecting telescope - advantages of reflecting telescope, Radio and Other Telescopes, Space-Based Telescopes. **[8 hours]**

MODULE 2

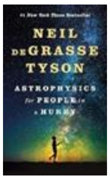
Solar system: The sun-physical and orbital data - Photosphere - Chromosphere - corona - solar prominences - sunspot - sunspot cycle - theory of sunspots - solar flare -mass of the sun - solar constant - temperature of the sun - source of solar energy - solar wind. Other members of the solar system – planets and satellites Bode's law - Asteroids - comets - Meteors. The Pluto Dilemma, The Asteroid Belt, Comets and the Oort Cloud, Size Comparisons of Celestial Bodies, **[15 hours]**

MODULE 3

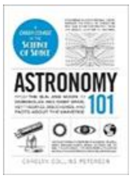
Stars and Galaxies: Stellar Evolution, elementary idea about birth and death of star, Chandrasekar limit, Supernovae, White Dwarfs and Planetary Nebulae, Brown Dwarfs, Neutron Stars, Black Holes, Pulsars and Quasar, Theories of the universe, galaxies and star clusters Origin of the universe - the big bang theory Hubble's law. Galaxies - types of galaxies - Milky Way - star clusters - open clusters - globular Clusters, Hubble deep field and ultra-deep field, Galactic collisions. **[8 hours]**

Space Exploration and Search for Life: A Brief History of Space Exploration, The First Man in Space, The Apollo Missions, Voyager, The International Space Station, Private Companies and NGOs, The Future of Human Space Exploration, The Challenges of Interstellar Travel. India on space, space mission of India: first satellite, space mission to moon, space mission to mars. The Search for Life in the Solar System: Europa and Enceladus, Exoplanets and Astrobiology. **[7 hours]**

6.0 TEXT BOOKS

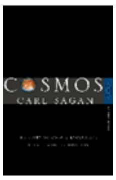


Name: Astrophysics for people in a hurry
Author: Neil de Grasse Tyson
Edition:
Publisher:
ISBN:

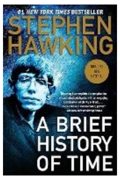


Name: Astronomy 101
Author: Carolyn Collins Peterson
Edition: 2013
Publisher: Adams Media
ISBN: 978-1440563591

7.0 REFERENCE BOOKS AND MATERIALS



Name: Cosmos
Author: Carl Sagan
Edition: 1983
Publisher: Abacus
ISBN: 978-0349107035



Name: A Brief History of Time: And Other Essays
Author: Stephen Hawking
Edition: 2015
Publisher: Bantam Doubleday Dell Publishing Group Inc
ISBN: 978-0553380163

8.0 MAPPING OF CLO TO PO AND PSO

The course outcomes and their mapping with program outcomes are specified in the table below

Course Learning Outcomes	Programme Outcomes (POs)												Programme Specific Outcome (PSOs)					
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6
CO1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

9.0 ASSESSMENT SCHEME

The evaluation system for this course consists of an 80% weightage on a comprehensive theory examination, which assesses students' understanding of various course topics, and a 20% weightage allocated to internal assessments, including internal examinations, assignments, class participation, and overall engagement in the course throughout the semester.

THEORY:

(A) Internal assessment: (20 marks): Continuous evaluation and internal assessment are implemented to foster and maintain a thorough understanding throughout the learning process. By regularly assessing comprehension through assignments, quizzes, and class participation, educators can address learning gaps promptly and support students in achieving deeper knowledge and proficiency in the subject matter.

(B) End-term examination (80 marks): The end-term examination serves as a culmination of students' learning in the course, assessing their comprehensive understanding and proficiency in various topics in the course. It provides a structured platform for students to demonstrate their knowledge, problem-solving abilities, and application of theoretical concepts, ultimately gauging their readiness to progress. Pattern of End term question paper

Section	Total Questions	Marks for each question	have to attempt	Total Marks
A	5	4	4	20
B	5	10	3	30
C	4	15	2	30

SKILL ENHANCEMENT COURESES

PHY-001-SE-0010: BASICS OF ELECTRONIC CIRCUITS

NCrF Level:	4.5	
Programme:	Four Year Undergraduate Programme	**Semester:** First
Course Category:	Skill Enhancement Course (SEC)	
Credit (L: T: P)	2: 0: 1	
Credit Hours	Theory: 30 Hours, Practical: 30 Hours	

1.0 COURSE LEARNING OBJECTIVES

This course provides a foundational understanding of electronic circuits, focusing on the practical design and troubleshooting of electronic instruments. The Learning objectives of the Courses are:

- Understand the principles of different DC power sources.
- Analyze the performance characteristics of batteries, solar cells, and DC power supplies.
- Design and implement simple DC power systems.
- Utilize tools and techniques for testing and maintaining DC power sources.
- Evaluate the efficiency and sustainability of DC power sources in various applications.

2.0 COURSE LEARNING OUTCOME

After completing this course, students will be able to,

CO	Outcomes
CO1:	Learn to use electrical quantities like voltage, current resistance as well as to apply fundamental laws of electronic circuit in the analysis and troubleshooting of electronic circuits
CO2:	Analyze and apply principles of alternating currents in electronic circuits and to measure AC parameters to solve and troubleshoot problems in AC circuits.
CO3:	Learn the basics and practical applications of solid-state devices like diodes, transistors and skills to troubleshoot electronic circuits with these components.
CO4:	Get comprehensive understanding of batteries and practical applications in various electronic devices and renewable energy systems.
CO5:	Analyze and construct various types of power supplies and per the requirements as well as to eliminate problem rise in power supplies used in daily life.
CO6:	Get skills to effectively operate and interpret data from electronic measuring instruments which enable them to test electronic components as well as to analyze any kind of electronic circuits.
CO7:	Understanding of safety precautions and compliance with regulations related to handling electronic components, circuits, and equipment to ensure safe operation and reliability.
CO8:	Able to prepare clear, structured, and concise scientific reports, effectively presenting laboratory works and findings with enhanced clarity.

3.0 SKILLS TO BE LEARNED

- To measure various parameters and electronic circuits like voltage, current, power etc.
- To analyze and understand the behaviour of AC and DC circuits.
- To design efficient electronic circuits to save electricity.
- To identify and select electronic components based on circuit requirements.
- To design circuits to meet specified criteria, including schematic capture, component placement.

- To Assembling circuits on breadboards and Printed Circuit Board
- To design and construct regulated power supply to provide stable voltage and current
- To identify and resolve common issues in electronic circuits through systematic troubleshooting
- To use safety protocols and regulatory standards in handling electronic circuits, and devices.

4.0 DETAILED CONTENTS OF THE COURSE: THEORY

Credit: 2 **Classroom Teaching: 30 Hours**

MODULE 1

Introduction to Electronics: Electronics and Electronic circuits, Basics electrical quantities - Voltage, Current, Resistance, and Power, Ohm's law, Series, parallel, and series-parallel combinations. Kirchhoff's Voltage Law and Kirchhoff's Current Law, voltage divider and current divider theorem Capacitor and Inductor – -series and parallel combination, Rules to analyze DC-sourced electrical circuits, Current and voltage drop across the DC circuit elements. basics of RC and LC circuits. **[5 hours]**

Alternating Correct (AC) Fundamentals: AC and DC Electricity, Real, imaginary and complex power components of AC source. Reactance and Impedance. Power factor. Single-phase and three-phase AC sources. Rules to analyze AC sourced electrical circuits. Saving energy and money. **[5 hours]**

Solid State devices: Resistor, Inductor and capacitor – classification and identification; Applications of semiconductor diode and transistor in electronic circuits, Thyristors, DIAC, TRIAC and SCR and their applications. **[5 hours]**

MODULE 2

Power sources: Primary Batteries - Alkaline, Zinc-Carbon, Silver Oxide, Zinc-Air, Secondary Batteries **-** Lithium-Ion, Lithium Polymer, Nickel-Cadmium, Nickel-Metal Hydride, Lead-Acid, Lithium Iron Phosphate, Flow Batteries, Solid-State, Sodium-Ion. Solar cell as DC power source, AC power source – generators, inverter – AC from solar cell **[5 hours]**

Power Supply: Block diagram of regulated power supply, Transformer, Rectifiers circuits – difference between Half wave, full-wave and bridge rectifiers, filter circuits - Choke input filter, Shunt capacitor filter-L section and section filters. Voltage regulators – diode and Transistor based voltage regulator, Three terminal regulators (78XX and 79XX), variable voltage regulators, SMPS and their advantages **[6 hours]**

Measuring and Testing Instruments: Digital vs. Analog Multimeter - Measuring Voltage, Current, and Resistance, LCR Meters, Clamp meter, IR thermometer, Oscilloscope, Testing of resistance, inductor, capacitor, diode, transistor etc. **[4 hours]**

5.0 DETAILED CONTENTS OF THE COURSE: PRACTICUM

Credit: 1 **Laboratory Work: 30 Hours**

In the practicum component of the course, students will undergo hands-on experience with electronic measuring instruments including necessary precautions. Initially, students will learn basic laboratory skills-required to analyze and troubleshoot electric circuits. They will enhance their skill through a series of laboratory experiments. During the work performed during the Laboratory hours is to be noted in a scientific manner

The teacher has the flexibility to introduce a wide range of laboratory experiments that directly correlate with and reinforce the theoretical concepts covered in the course curriculum. These experiments serve as practical applications of the theoretical principles discussed in lectures.

Part 1: Laboratory skill:

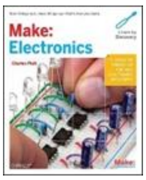
1) Identification of electronic components and measurement of their ratings.
2) Use of breadboard and hook-up wire in a laboratory experiment.
3) Design of circuit in Breadboard and hook up wire.
4) Use of Multimeter and LCR meter for measuring resistance, voltage, current etc.
5) Use of Oscilloscope for the analysis of an AC signal
6) Testing of resistance, inductor, capacitor, diode, transistor etc.
7) Soldering of electronic components
8) Printed circuit board soldering

Part 2: Experiment:

1) Verification of ohm's law
2) Kirchhoff's Voltage Law and Kirchhoff's Current Law
3) Verification of series and parallel combination formula of resistances
4) Verification of series and parallel combination formula of inductance
5) Verification of series and parallel combination formula of capacitance
6) Verification of formula for voltage divider theorem
7) Verification of formula for current divider theorem
8) Building and testing of Half wave, full-wave and bridge rectifier circuits
9) Building and testing of input choke filter and Shunt capacitor filter
10) Building of L section and section filters.
11) Building of Zener diode-based voltage regulator
12) Building of Transistor based voltage regulator.
13) Construction of Three terminal regulators (78XX and 79XX)
14) Development of a variable power supply.
15) Construction of a variable power supply from 220 V AC supply.

6.0 TEXT BOOKS

Name: Getting Started in Electronics
Author: Forrest. M. Mims.
Edition: 3rd Ed. (2003)
Publisher: Master Publishing, Inc.
ISBN: 978-0945053286

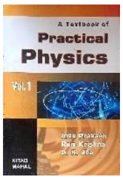


Name: Make Electronics – Learning by Discovery
Author: Charles Platt
Edition: 2nd Ed.(2015)
Publisher: Make Community, LLC
ISBN: 978-1680450262

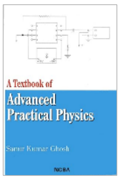
Name: A Text book in Electrical Technology
Author: Paul Scherz, Simon Monk
Edition: 4th Ed.(2016)
Publisher: McGraw Hill TAB
ISBN: 978-1259587542

7.0 REFERENCE BOOKS AND MATERIALS

Name: Make: More Electronics: Journey Deep Into the World of Logic Chips, Amplifiers, Sensors, and Randomicity
Author: Charles Platt
Edition: 1st Ed.(2014)
Publisher: Make Community, LLC
ISBN: 978-1449344047



Name: A textbook of Practial Physics
Author: Indu Prakash, Rama Krishna, A.K. Jha
Edition: 2011
Publisher: Kitab Mahal
ISBN: 978-8122504163



Name: A Textbook of Advanced Practical Physics
Author: Samir Kumar Ghosh
Edition: 2008
Publisher: New Central Book Agency
ISBN: 978-8173812439

6.0 MAPPING OF CLO TO PO AND PSO

The course outcomes and their mapping with program outcomes are specified in the table below

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CO3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

9.0 ASSESSMENT SCHEME

The evaluation system for this course consists of an 80% weightage on a comprehensive theory examination, which assesses students' understanding of various course topics, and a 20% weightage allocated to internal assessments, including internal examinations, assignments, class participation, and overall engagement in the course throughout the semester.

THEORY:

(A) Internal assessment: (20 marks): Continuous evaluation and internal assessment are implemented to foster and maintain a thorough understanding throughout the learning process. By regularly assessing comprehension through assignments, quizzes, and class participation, educators can address learning gaps promptly and support students in achieving deeper knowledge and proficiency in the subject matter.

(B) End-term examination (80 marks): The end-term examination serves as a culmination of students' learning in the course, assessing their comprehensive understanding and proficiency in various topics in the course. It provides a structured platform for students to demonstrate their knowledge, problem-solving abilities, and application of theoretical concepts, ultimately gauging their readiness to progress. Pattern of End term question paper

Section	Total Questions	Marks for each question	have to attempt	Total Marks
A	5	4	4	20
B	5	10	3	30
C	4	15	2	30

PRACTICUM:

(A) Internal assessment: (20 marks): In the internal assessment of the practicum components, the student's performance, understanding, skills, sincerity, and involvement in laboratory work during the entire semester are evaluated.

(B) End-term examination (80 marks): The ability to apply theoretical knowledge to real-world situations is the fundamental criterion used in the End Term examination. It typically involves students' activity on randomly assigned laboratory works and the Laboratory Report (Notebook) on the performed work in the entire semester. In the End examination, the student must complete randomly assigned tasks and prepare a report on their work, including appropriate conclusions. The mark distribution for the End term examination as follows.

Activity	Marks
Laboratory work in the Examination	40
Laboratory Notebook	20
Presentation/Viva-voce	20

PHY 001 SE 0020: ELECTRICITY IN DAILY LIFE

NCrF Level:	4.5	
Programme:	Four-Year Undergraduate Programme	**Semester:** Second
Course Category:	Skill Enhancement Course (SEC)	
Credit (L: T: P)	2: 0: 1	
Credit Hours	Theory: 30 Hours, Practical: 30 Hours	

1.0 COURSE LEARNING OBJECTIVES

The course provides basic knowledge about the daily generation, transmission, distribution and use of electricity. The Learning Objectives of this course are:

- Understanding fundamental principles of electricity and electrical circuits.
- Exploring the practical applications of electricity in household appliances and everyday devices.
- Learning safety protocols and precautions related to electrical installations and usage.
- Analyzing energy efficiency and conservation strategies in daily electricity consumption.
- Gaining skills in basic electrical troubleshooting and maintenance.
- Examining the impact of electricity on modern living and sustainability.

2.0 COURSE LEARNING OUTCOME

After completing this course, students will be able to,

CO	Outcomes
CO1:	Learn the basics of alternating current of household electricity and their source and characteristics like RMS value, peak value, frequency, phase etc.
CO2:	Learn the principles and systems used to generate electricity and their cost-effective distribution to factories, Universities, colleges and houses.
CO3:	Get the l knowledge and hands-on skills for safely designing, installing, maintaining and troubleshooting residential electrical wiring systems.
CO4:	Learn to analysis, identify analyse and mitigation of faults in electrical power systems as well as to design electrical protection schemes using different circuit breakers.
CO5:	Learn the operational principles, design, and implement electric motors customized for devices like fans, mixers and other relevant equipment in both industrial and residential environments.
CO6:	Learn the operational principles inverters and UPS systems and get the skill to troubleshoot these systems in a systematic manner.
CO7:	Able to prepare clear, structured, and concise scientific reports, effectively presenting laboratory works and findings with enhanced clarity.

3.0 SKILLS TO BE LEARNED

- Basics of AC current generation and distribution
- Skills of design and construct household wiring
- To troubleshoot different power backup systems.
- Principles and techniques of electrical items used at home
- Electrical wiring and measures for electrical protection.
- Physics of generators, transformers, electric motors

4.0 DETAILED CONTENTS OF THE COURSE: THEORY

Credit: 2 **Classroom Teaching: 30 Hours**

MODULE 1

Basics of electricity: Electrical charge, Current and voltage, Identification and characteristics of electrical components (resistors, capacitors, inductors), DC Power supply- batteries, AC currents - single phase and three phase, RMS and peak value, electric power and energy, Instruments to measure current, voltage, power in DC and AC circuits, power calculation, energy consumption and billing, Energy efficiency and conservation strategies, **[6 hours]**

Generation and Transmission electricity: Overview of electricity generation methods (fossil fuels, renewables), Power stations, Generators and Transformers, Distribution of electricity to factory, University, college and to home. **[2 hours]**

Electrical Wiring: Types of Wiring systems, Electrical Symbols and Diagrams, abbreviations, blueprints; Conductors and Cables – types of conductors, Types, characteristics and specifications of electrical cables, selection criteria based on requirements, Voltage drops and losses across cables, Solid and stranded cable. Conduit. Cable trays. Splices: wire nuts, crimps, terminal blocks, split bolts, and solder. Design and construction of the extension board. **[7 hours]**

MODULE 2

Faults and Electrical Protection: Classification and Faults of electric circuits, Overloading and Short Circuits, Fuses and disconnect switches. Protective Relays. Circuit breakers, overcurrent Protection devices - MCB, MCCB, ELCB, RCCB and RCD, Ground-fault protection. Grounding and isolating. Phase reversal. Surge protection. **[5 hours]**

Electric Motors in Household Appliances: AC and DC motors – single phase and three phase, speed and power of electric motor, motor based electronic appliances- fan, mixer grinder; electric vehicles; fluorescent lamps, LED lamp, water heater - storage and instant types, electric iron, microwave oven, Stabilizer, fridge. **[7 hours]**

Alternative power source: Inverter and UPS, online UPS and offline UPS, Solar inverter, Grid connection of solar energy. **[3 hours]**

5.0 DETAILED CONTENTS OF THE COURSE: PRACTICUM

Credit: 1 **Laboratory Work: 30 Hours**

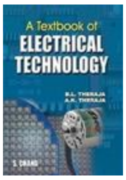
In the practicum component of the course, students will undergo a number of activity and experiments related to current electricity, house hold wiring systems, electronic appliances used in daily life.
The teacher has the flexibility to introduce a wide range of laboratory experiments that directly correlate with and reinforce the theoretical concepts covered in the course curriculum. These experiments serve as practical applications of the theoretical principles discussed in lectures.

Laboratory activity and skills:

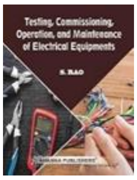
1. Learn and apply electrical safety procedures; familiarize with common electrical tools.
2. Construct simple series and parallel circuits; understand basic wiring techniques.
3. Verify Ohm's Law using 220V AC supply
4. Verify Ohm’s Law and calculate resistances in series and parallel circuits.
5. Explore the behavior of voltage and current in series and parallel AC circuits.
6. Measure and understand the power factor in AC circuits.
7. Observe and analyze the waveforms of voltage and current in AC circuits.

8. Measure and analyze the power consumption of various household appliances.
9. Measure the efficiency of a transformer operating at 220V AC.
10. Study the resonance phenomenon in RLC circuits using 220V AC.
11. Analyze the operating characteristics of an induction motor.
12. Understand the working of a capacitor start induction motor.
13. Interpret and create electrical schematics for simple circuits.
14. Apply residential wiring standards and techniques in a mock setup.
15. Use a Multimeter to measure voltage, current, and resistance; perform continuity tests.
16. Identify and resolve faults in electrical circuits.
17. Test the operation of a GFCI to ensure electrical safety.
18. Learn the National Electrical Code (NEC) standards and apply them to electrical designs.
19. Understand and wire systems for solar and wind power.
20. Integrate various electrical systems into a comprehensive project.

6.0 TEXT BOOKS

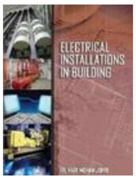


Name: A Textbook of Electrical Technology
Author: B.L. Theraja and A. K. Theraja
Edition: 24^{th} Ed. (2005)
Publisher: S. Chand.
ISBN: 978-8121924412

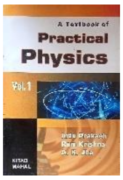


Name: Testing, Commissioning, Operation and Maintenance of Electrical Equipment's
Author: Prof. Sunil S. Rao
Edition: 1991
Publisher: Khanna Publishers
ISBN: 978-8174091857

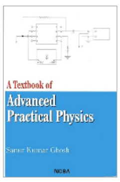
7.0 REFERENCE BOOKS AND MATERIALS



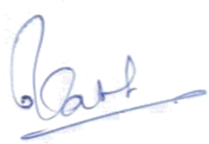
Name: Electrical Installations in Building
Author: Hari Mohan Johri
Edition: 2010
Publisher: KW Publishers Pvt Ltd
ISBN: 978-9380502472



Name: A textbook of Practial Physics
Author: Indu Prakash, Rama Krishna, A.K. Jha
Edition: 2011
Publisher: Kitab Mahal
ISBN: 978-8122504163



Name: A Textbook of Advanced Practical Physics
Author: Samir Kumar Ghosh
Edition: 2008
Publisher: New Central Book Agency
ISBN: 978-8173812439



6.0 MAPPING OF CLO TO PO AND PSO

The course outcomes and their mapping with program outcomes are specified in the table below

Course Learning Outcomes	Programme Outcomes (POs)												Programme Specific Outcome (PSOs)					
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CO2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

9.0 ASSESSMENT SCHEME

The evaluation system for this course consists of an 80% weightage on a comprehensive theory examination, which assesses students' understanding of various course topics, and a 20% weightage allocated to internal assessments, including internal examinations, assignments, class participation, and overall engagement in the course throughout the semester.

THEORY:

(A) Internal assessment: (20 marks): Continuous evaluation and internal assessment are implemented to foster and maintain a thorough understanding throughout the learning process. By regularly assessing comprehension through assignments, quizzes, and class participation, educators can address learning gaps promptly and support students in achieving deeper knowledge and proficiency in the subject matter.

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Pattern of End term question paper

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PRACTICUM:

(A) Internal assessment: (20 marks): In the internal assessment of the practicum components, the student’s performance, understanding, skills, sincerity, and involvement in laboratory work during the entire semester are evaluated.

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Activity	Marks
Laboratory work in the Examination	40
Laboratory Notebook	20
Presentation/Viva-voce	20

PHY-001-SE-0030: FUNDAMENTALS OF PYTHON

NCrF Level:	5.0	
Programme:	Four-Year Undergraduate Programme	**Semester:** Third
Course Category:	Skill Enhancement Course (SEC)	
Credit (L: T: P)	2: 0: 1	
Credit Hours	Theory: 30 Hours, Practical: 30 Hours	

1.0 COURSE LEARNING OBJECTIVES

This course provides foundational computer programming principles and basics of Python Programming Concepts as well as their use in problem-solving. The Learning Objectives of this course are:

- To provide a well-rounded skill set in programming, algorithm design, and the use of flowcharts
- Develop, write, and debug programs using variables, control structures, and functions.
- Formulate, analyze, and optimize algorithms-based programs for problem-solving,
- To apply logical and critical thinking to evaluate the efficiency algorithms and their implementation
- Employ systematic debugging to identify and resolve issues within programs and algorithms.

2.0 COURSE LEARNING OUTCOME

After completing this course, students will be able to,

CO	Outcomes
CO1:	Get skill set in programming, algorithm design, and the creation and interpretation of flowcharts which enable them to effectively solve computational problems.
CO2:	Effectively use Python distributions and tools such as Anaconda, Spyder, Jupyter Notebooks, and interpreter for developing, executing, and managing Python code in diverse environments.
CO3:	Develop, write, and debug programs using fundamental programming constructs to solve a variety of computational problems.
CO4:	Utilize control structures such as conditional statements (if, elif, else) and loops (for, while) to control the flow of their programs effectively.
CO5:	design, implement and utilize Python functions effectively to modularize code, enhance reusability, and facilitate efficient program development.
CO6:	To effectively utilize and integrate Python libraries and modules to extend program functionality, manage dependencies, and enhance the modularity and efficiency of their code.
CO7:	Able to prepare clear, structured, and concise scientific reports, effectively presenting laboratory works and findings with enhanced clarity.

3.0 SKILLS TO BE LEARNED

- Skill to use flow charge in design, testing and debug algorithms and computer programmes.
- Develop, write, and debug Python programs as per the requirements.
- Formulate, analyze, and optimize algorithms-based programs for problem-solving,
- To formulate, analyze, and optimize algorithms to develop programs to solve complex problems.
- Use of and integrate Python libraries and modules.

4.0 DETAILED CONTENTS OF THE COURSE: THEORY

Credit: 2 **Classroom Teaching: 30 Hours**

MODULE 1

Programming, Algorithms and Flowcharts: Overview of programming concepts and its Importance in problem-solving, type of programming languages, High level languages – advantages and disadvantages. Algorithms and Flowcharts - their importance in problem-solving, Characteristics of good algorithms,: pseudocode, efficiency, correctness, understanding problem-solving strategies: brute force, divide and conquer, greedy algorithms, dynamic programming, problem-solving strategies to real-world problems, Flowchart and its applications - Creating flowcharts to represent algorithms and processes. **[3 Hours]**

Introduction to Python: History of Python Programming Language, thrust areas of Python in physics, Integrated Development Environments, installation and use of python distribution: Anaconda, Spyder, Jupiter notebooks, The Python interpreter, the print statement, comments, Python as simple calculator, objects and expressions, variables (numeric, character and sequence types) and assignments. **[5 Hours]**

Programming with Python: Designing a Program, identifiers, keywords, operators, and expressions. Arithmetic, Logical and Assignment operators in Python program, Precedence, Data types: Basic data types: Strings and numbers, displaying an output, type conversion, basic string operations and methods, format specifiers. Tuples - immutable sequences, creating tuple, basic tuple operations. Lists - mutable sequences, basic list operations, List methods Dictionaries - basic dictionary operations, dictionary method User input variable. **[7 Hours]**

MODULE 2

Control Structures: Conditional operations, Decision Structures - If, If -else, if ….elif…..else, nested if decision flow statements. Repetition Structures - condition controlled: while loop. Count controlled: for loop, sentinels, continue and break statements, try and except statements, List comprehension, Boolean expressions and logical operators, using conditional statements to control program flow **[4 Hours]**

Functions: Inbuilt functions and user-defined functions , local and global variables, scope of variable, passing functions, value returning functions, void functions, modules, importing modules, math module, making new modules. void function **[4 Hours]**

File Handling: Reading from and writing to files, Different file modes (read, write, append), Handling file exceptions **[1 Hours]**

Introduction to Libraries and Modules: Overview of Python standard library, Importing and using modules, Exploring popular third-party libraries (e.g., NumPy, pandas), NumPy: -Array object, creating array, matrix, indexing, slicing, resizing, reshaping, arithmetic operations, functions, matrices and vector operations Matplotlib: basic plotting, Scipy: Linear algebra operations, equation solving **[6 Hours]**

5.0 DETAILED CONTENTS OF THE COURSE: PRACTICUM

Credit: 1 **Laboratory Work: 30 Hours**

In the practicum component of the course, students will undergo a number of exercises to learn the basic syntax of Python and their use in real-world problems as listed below.

- **Python Programming Environment:** Setting up Python environment on local machine or online IDE, Basic usage of Python interpreter and IDE, Writing and running Python scripts,
- **Python Basics Review:** Python syntax, data types, and operators, Practice exercises to reinforce understanding of Python fundamentals
- **Control Structures**: Practice exercises on conditional statements (if-else) and loops (for, while) Solving problems using control structures
- **Functions and Modular Programming**: Writing and calling functions in Python, Modularizing code through function decomposition, Practice exercises on function implementation and usage

- **Working with Data Structures:** Practice exercises on lists, tuples, dictionaries, and sets, Solving problems involving data manipulation and manipulation
- **File Handling and Input/Output Operations**: Reading from and writing to files in Python, Handling different file formats (text files, CSV files), Practice exercises on file input/output operations
- **Introduction to Python Libraries and Modules:** Python libraries - NumPy, pandas, Matplotlib etc., Use of third-party modules, Practice exercises on using libraries for data manipulation and visualization

Suggestive list for exercise:

A) Basics Programs:

1) *Python program to add two numbers*
2) *Maximum of two numbers in Python*
3) *Python Program for factorial of a number*
4) *Python Program for simple interest*
5) *Python Program for compound interest*
6) *Python Program to check Armstrong Number*
7) *Python Program for Program to find area of a circle*
8) *Python program to print all Prime numbers in an Interval*
9) *Python program to check whether a number is Prime or not*
10) *Python Program for n-th Fibonacci number*
11) *Python Program for How to check if a given number is Fibonacci number?*
12) *Python Program for n\’th multiple of a number in Fibonacci Series*
13) *Program to print ASCII Value of a character*
14) *Python Program for Sum of squares of first n natural numbers*
15) *Python Program for cube sum of first n natural numbers*

B) Programs with Array

1) *Python Program to find sum of array*
2) *Python Program to find largest element in an array*
3) *Python Program for array rotation*
4) *Python Program for Reversal algorithm for array rotation*
5) *Python Program to Split the array and add the first part to the end*
6) *Python Program for Find remainder of array multiplication divided by n*
7) *Python Program to check if given array is Monotonic*

C) Programs with List

1) *Python program to interchange first and last elements in a list*
2) *Python program to swap two elements in a list*
3) *Python | Ways to find length of list*
4) *Python | Ways to check if element exists in list*
5) *Different ways to clear a list in Python*
6) *Python | Reversing a List*
7) *Python program to find sum of elements in list*
8) *Python | Multiply all numbers in the list*
9) *Python program to find smallest number in a list*
10) *Python program to find largest number in a list*
11) *Python program to find second largest number in a list*
12) *Python program to find N largest elements from a list*
13) *Python program to print even numbers in a list*
14) *Python program to print odd numbers in a List*
15) *Python program to print all even numbers in a range*
16) *Python program to print all odd numbers in a range*
17) *Python program to print positive numbers in a list*
18) *Python | Count occurrences of an element in a list*

19) *Python | Remove empty tuples from a list*
20) *Python | Program to print duplicates from a list of integers*
21) *Python program to find Cumulative sum of a list*
22) *Python | Sum of number digits in List*
23) *Break a list into chunks of size N in Python*
24) *Python | Sort the values of first list using second list*

D) Programs with Matrix

1) *Python program to add two Matrices*
2) *Python program to multiply two matrices*
3) *Python program for Matrix Product*
4) *Adding and Subtracting Matrices in Python*
5) *Transpose a matrix in Single line in Python*
6) *Python | Matrix creation of n*n*
7) *Python | Get Kth Column of Matrix*
8) *Python – Vertical Concatenation in Matrix*

E) Programs with String

1) *Python program to check if a string is palindrome or not*
2) *Python program to check whether the string is Symmetrical or Palindrome*
3) *Reverse words in a given String in Python*
4) *Ways to remove i'th character from string in Python*
5) *Python | Check if a Substring is Present in a Given String*
6) *Python – Words Frequency in String Shorthands*
7) *Python – Convert Snake case to Pascal case*
8) *Find length of a string in python (4 ways)*
9) *Python program to print even length words in a string*
10) *Python program to accept the strings which contains all vowels*
11) *Python | Count the Number of matching characters in a pair of string*
12) *Remove all duplicates from a given string in Python*
13) *Python – Least Frequent Character in String*
14) *Python | Maximum frequency character in String*
15) *Python | Program to check if a string contains any special character*
16) *Generating random strings until a given string is generated*
17) *Find words which are greater than given length k*
18) *Python program for removing i-th character from a string*
19) *Python program to split and join a string*
20) *Python | Check if a given string is binary string or not*
21) *Python program to find uncommon words from two Strings*
22) *Python – Replace duplicate Occurrence in String*
23) *Python – Replace multiple words with K*
24) *Python | Permutation of a given string using inbuilt function*
25) *Python | Check for URL in a String*
26) *Execute a String of Code in Python*
27) *String slicing in Python to rotate a string*
28) *String slicing in Python to check if a string can become empty by recursive deletion*
29) *Python Counter| Find all duplicate characters in string*
30) *Python – Replace all occurrences of a substring in a string*

F) Programs with Dictionary

1) *Python – Extract Unique values dictionary values*
2) *Python program to find the sum of all items in a dictionary*
3) *Python | Ways to remove a key from dictionary*
4) *Ways to sort list of dictionaries by values in Python – Using itemgetter*

5) *Ways to sort list of dictionaries by values in Python – Using lambda function*
6) *Python | Merging two Dictionaries*
7) *Python – Convert key-values list to flat dictionary*
8) *Python – Insertion at the beginning in OrderedDict*
9) *Python | Check order of character in string using OrderedDict( )*
10) *Dictionary and counter in Python to find winner of election*
11) *Python – Append Dictionary Keys and Values (In order) in dictionary*
12) *Python | Sort Python Dictionaries by Key or Value*
13) *Python – Sort Dictionary key and values List*
14) *Handling missing keys in Python dictionaries*
15) *Python dictionary with keys having multiple inputs*
16) *Print anagrams together in Python using List and Dictionary*
17) *K'th Non-repeating Character in Python using List Comprehension and OrderedDict*
18) *Check if binary representations of two numbers are anagram*
19) *Python Counter to find the size of largest subset of anagram words*
20) *Python | Remove all duplicates words from a given sentence*
21) *Python Dictionary to find mirror characters in a string*
22) *Counting the frequencies in a list using dictionary in Python*
23) *Python | Convert a list of Tuples into Dictionary*
24) *Python counter and dictionary intersection example (Make a string using deletion and rearrangement)*
25) *Python dictionary, set and counter to check if frequencies can become same*
26) *Scraping And Finding Ordered Words In A Dictionary using Python*
27) *Possible Words using given characters in Python*
28) *Python – Keys associated with Values in Dictionary*

G) ***Programs with Tuple***

1) *Python program to Find the size of a Tuple*
2) *Python – Maximum and Minimum K elements in Tuple*
3) *Create a list of tuples from given list having number and its cube in each tuple*
4) *Python – Adding Tuple to List and vice – versa*
5) *Python – Closest Pair to Kth index element in Tuple*
6) *Python – Join Tuples if similar initial element*
7) *Python – Extract digits from Tuple list*
8) *Python – All pair combinations of 2 tuples*
9) *Python – Remove Tuples of Length K*
10) *Sort a list of tuples by second Item*
11) *Python program to Order Tuples using external List*
12) *Python – Flatten tuple of List to tuple*
13) *Python – Convert Nested Tuple to Custom Key Dictionary*

H) **Programs for Searching and Shorting**

1) *Python Program for Binary Search (Recursive and Iterative)*
2) *Python Program for Linear Search*
3) *Python Program for Insertion Sort*
4) *Python Program for Recursive Insertion Sort*
5) *Python Program for QuickSort*
6) *Python Program for Iterative Quick Sort*
7) *Python Program for Selection Sort*
8) *Python Program for Bubble Sort*
9) *Python Program for Merge Sort*
10) *Python Program for Iterative Merge Sort*
11) *Python Program for Heap Sort*
12) *Python Program for Counting Sort*

13) *Python Program for ShellSort*
14) *Python Program for Topological Sorting*
15) *Python Program for Radix Sort*
16) *Python Program for Binary Insertion Sort*
17) *Python Program for Bitonic Sort*
18) *Python Program for Comb Sort*
19) *Python Program for Pigeonhole Sort*
20) *Python Program for Cocktail Sort*
21) *Python Program for Gnome Sort*
22) *Python Program for Odd-Even Sort / Brick Sort*
23) *Python Program for BogoSort or Permutation Sort*
24) *Python Program for Cycle Sort*
25) *Python Program for Stooge Sort*

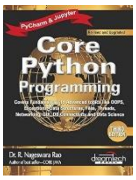
I) Program with Date and time

1) *Python program to get Current Time*
2) *Get Current Date and Time using Python*
3) *Python | Find yesterday's, today's and tomorrow's date*
4) *Python program to convert time from 12 hour to 24 hour format*
5) *Python program to find difference between current time and given time*
6) *Python Program to Create a Lap Timer*
7) *Convert date string to timestamp in Python*
8) *How to convert a timestamp string to a datetime object in Python?*

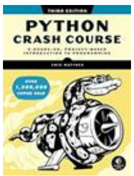
J) Programs with 'functions'

1) *Define a function that accepts 2 values and returns its sum, subtraction and multiplication.*
2) *Define a function that accepts roll numbers and returns whether the student is present or absent.*
3) *Define a function in python that accepts 3 values and returns the maximum of three numbers.*
4) *Define a function that accepts a number and returns whether the number is even or odd.*
5) *Define a function which counts vowels and consonants in a word.*
6) *Define a function that returns Factorial of a number.*
7) *Define a function that accepts lowercase words and returns uppercase words.*
8) *Define a function that accepts radius and returns the area of a circle*.

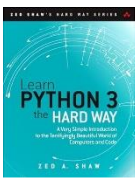
6.0 TEXT BOOKS



Name: Core Python Programming
Author: R. Nageswara Rao
Edition: 2000
Publisher: Dreamtech Press
ISBN: 978-8121905992

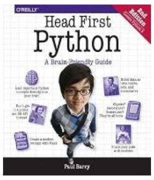


Name: Python Crash Course: A Hands-On, Project-Based Introduction to Programming
Author: Eric Matthes
Edition: 3rd Ed.
Publisher: No Starch Press,US
ISBN: 978-1718502703

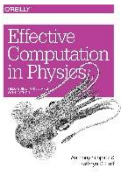


Name: Learn More Python 3
Author: Zed A. Shaw
Edition: 1st Ed. (2017)
Publisher: Addison-Wesley
ISBN: 978-0134692883

7.0 REFERENCE BOOKS AND MATERIALS



Name: Head First Python
Author: Paul Barry
Edition: 2nd Ed.
Publisher: O'Reilly
ISBN: 978-1491919538



Name: Effective Computation in Physics: Field Guide to Research with Python
Author: Anthony Scopatz, Kathryn D. Huff
Edition: 2015
Publisher: O'Reilly
ISBN: 978-1491901533

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