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UNIVERSITY OF DELHI

Bachelor of Science in Physical Sciences
Discipline: Electronics

(Effective from Academic Year 2019-20)

Revised Syllabus as approved by

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Applicable for students enrolled in Regular Colleges.

List of Contents

Page No.

Preamble

Higher Education in India is in need of reform. On the one hand, while there is a need for increased access to higher education in the country, it is also necessary to improve the quality of higher education. New initiatives and sustained efforts are needed to develop and enhance the spirit of enquiry, analytical ability and comprehension skills of the young generation of students. An emerging knowledge based society requires that they are able to acquire and generate new knowledge and skills, and can creatively apply them to excel in their chosen vocations. Our higher education system needs to inculcate exemplary citizenship qualities and motivate students to contribute to the society at large. Such abilities and qualities of our youth will be crucial for the country to face the challenges of the future.

One of the reforms in undergraduate (UG) education, initiated by the University Grants Commission (UGC) at the national level in 2018, is to introduce the Learning Outcomes-based Curriculum Framework (LOCF) which makes it student-centric, interactive and outcome-oriented with well-defined aims and objectives.

The Department of Physics and Astrophysics, University of Delhi took up the task of drafting the LOCF for UG Physics courses according to guidelines sent in March 2019 by the Undergraduate Curriculum Review Committee (UGCRC)-2019 of the University of Delhi. The Committee of Courses of the Department constituted a Steering Committee, whose composition is given in Annexure 1A, to plan and formulate the LOCF for UG Physics courses of the University. The Steering Committee formed Subject Working Groups (Annexure 1B) to formulate the content of different sets of courses. The Subject Working Groups included teachers from more than twenty colleges of the University, who have experience of teaching the respective courses. About eighty faculty members from the Department of Physics and Astrophysics and Physics Departments of colleges of the University have contributed to this important task. The inputs of the Subject Working Groups were compiled, and the present document prepared by a final drafting team (Annexure 1C).

The University of Delhi offers the undergraduate B.Sc. (Honours) Physics programme, the B.Sc. Physical Sciences programme with Physics and Electronics disciplines, as well as general elective courses in Physics for students of Honours programmes in disciplines other than Physics. The LOCF has been prepared for all of the above.

An earlier draft of the LOCF of the University of Delhi was put in the public domain for stakeholders' comments in May 2019. This was a revised version of the existing Choice Based Credit System (CBCS) undergraduate programme at the University of Delhi. We thank the stakeholders who took time and made effort to give us feedback on the earlier draft. Many of the comments received have helped us improve the LOCF draft.

We acknowledge the use of the document "Learning Outcomes based Curriculum Framework (LOCF) for Undergraduate Programme B.Sc. (Physics) 2019" put up by the UGC on its website in May 2019 (https://www.ugc.ac.in/pdfnews/1884134_LOCF-Final_Physics-report.pdf) and prepared by its Subject Expert Committee for Physics. This document has helped in clarifying the features of the LOCF and is the original source of a significant part of the text of the present document.

Keywords

Ability Enhancement Compulsory Course (AECC);

Core Courses (CC);

Discipline Specific Electives (DSE);

Learning Outcome-based Curriculum Frame work (LOCF);

Course Learning Outcomes (CLO);

Program Learning Outcomes (PLO);

Skill Enhancement Courses (SEC);

Teaching Learning Processes (TLP).

Learning Outcomes-Based Curriculum Framework for Undergraduate Education in Physics

1. INTRODUCTION

The learning outcomes-based curriculum framework for a B.Sc degree in Physical Sciences with Electronics discipline is intended to provide a comprehensive foundation to the subject, and to help students develop the ability to successfully continue with further studies and research in the subject. The framework is designed to equip students with valuable cognitive abilities and skills so that they are successful in meeting diverse needs of professional careers in a developing and knowledge-based society. The curriculum framework takes into account the need to maintain globally competitive standards of achievement in term of the knowledge and skills in Electronics, as well develop scientific orientation, enquiring spirit, problem solving skills and values which foster rational and critical thinking.

Due to the extreme diversity of our country, a central university like the University of Delhi gets students from very different academic backgrounds, regions and language zones. While maintaining high standards, the learning outcome-based curriculum provides enough flexibility to teachers and colleges to respond to diverse needs of students.

The learning outcome-based curriculum framework for undergraduate courses in Physical Sciences with Electronics discipline also allows for flexibility and innovation in the programme design to adopt latest teaching and assessment methods, and include introduction to news areas of knowledge in the fast-evolving subject domains. The process of learning is defined by the following steps which form the basis of final assessment of the achievement at the end of the program.

(i) Development of an understanding and knowledge of basic Electronics. This involves exposure to basics facts of nature discovered by Physics and Electronics through observations and experiments. The other core component of this development is introduction to Electronics concepts and principles, their theoretical relationships in laws of Electronics, and deepening of their understanding via appropriate problems.

(ii) The ability to use this knowledge to analyze new situations and learn skills and tools like laboratory techniques, computational methods, applied mathematics, embedded systems and smart modules to find solution, interpret results and make meaningful predictions.

(iii) The ability to synthesize the acquired knowledge and experience for an improved comprehension of the physical problems and to create new skills and tools for their possible solutions.

2.LEARNING OUTCOME-BASED CURRICULUM FRAMEWORK IN B.Sc. PHYSICAL SCIENCES PROGRAMME having Electronics discipline

Note: *There is one B.Sc. Physical Sciences Programme, namely B.Sc. Physical Sciences with Physics, Electronics, and Mathematics (PEM) where Electronics is one of the disciplines.*

2.1 NATURE AND EXTENT OF THE PROGRAMME IN B.Sc. PHYSICAL SCIENCES WITH ELECTRONICS DISCIPLINE

The UG programs, B.Sc. Physical Science with Electronics discipline is builds on the basic Physics taught at the +2 level in all the schools in the country. Ideally, the +2 senior secondary school education should aim and achieve a sound grounding in understanding the basic and applied Physics with sufficient content of topics from modern Physics and contemporary areas of exciting developments in physical sciences. The curricula and syllabi should be framed and implemented in such a way that the basic connection between theory and experiment and its importance in understanding electronics is made clear to students. This is very critical in developing a scientific temperament and the urge to learn and innovate in electronics and other allied disciplines. Unfortunately the condition of our school system in most parts of the country lacks the facilities to achieve the above goal, and it is incumbent upon the college/university system to fill gaps in the scientific knowledge and understanding of our country's youth who complete school curricula and enter university education.

Electronics, a subdivision of Physics, is an experimental science that studies systematically the applied aspects of the laws of nature operating at length scales from the sub-atomic domains to the entire universe. The scope of electronics as a subject is very broad. The core areas of study within the disciplinary/subject area of an UG programme in Electronics are: Network Analysis and Analog Electronics, Linear and Digital Integrated Circuits, Communication Electronics, and Microprocessor and Microcontroller, and specialized tools of electronics and their applications in different branches of the subject. Along with the theoretical course work students also learn laboratory methods for different branches of Electronics, specialized electronics tools and software, and scientific report writing. The latest addition to Electronics pedagogy incorporated in the LOCF framework is computational and Laboratory work, which involves adaptation of problems for algorithmic solutions, as well as modelling and simulation of Electronics circuits and embedded system. The elective modules of the framework offer students choice to gain knowledge and expertise in more specialized domains of Electronics like Semiconductor Devices, Instrumentation, Digital Signal Processing, Verilog and FPGA based system Design, Photonic Devices, Power Electronics, Antenna Theory, wireless Network

The Electronics-based knowledge and skills learnt by students also equip them to be successful in careers other than research and teaching in Electronics.

2.2 AIMS OF BACHELORS DEGREE PROGRAMME IN B.Sc. PHYSICAL SCIENCES WITH ELECTRONICS DISCIPLINE

The LOCF based UG educational program in B.Sc. Physical Science with Electronics aims to

- create the facilities and learning environment in educational institutions to consolidate the knowledge acquired at +2 level, motivate students to develop a deep interest in applied Physics and Electronics, and to gain a broad and balanced knowledge and understanding of physical concepts, principles and theories of Electronics.
- provide opportunities to students to learn, design and perform experiments in lab, gain an understanding of laboratory methods, design and analysis of electronic circuits and report writing, and acquire a deeper understanding of concepts, principles and theories learned in the classroom through laboratory demonstration, and computational problems and modelling.
- develop the ability in students to apply the knowledge and skills they have acquired to get to the solutions of specific theoretical and applied problems in Electronics.
- to prepare students for pursuing the interdisciplinary and multidisciplinary higher education and/or research in interdisciplinary and multidisciplinary areas, as Electronics is among the most important branches of applied science necessary for interdisciplinary and multidisciplinary research.
- to prepare students for developing new industrial technologies and theoretical tools for applications in diverse branches of the corporate and economic life of the country, as Electronics is one of the branches of applied science which contribute directly to technological development, and
- in light of all of the above to provide students with the knowledge and skill base that would enable them to undertake further studies in Electronics and related areas, or in interdisciplinary/multidisciplinary areas, or join and be successful in diverse professional streams including entrepreneurship and startups.

3. GRADUATE ATTRIBUTES IN B.Sc. PHYSICAL SCIENCES WITH ELECTRONICS DISCIPLINE

Some of the characteristic attributes of a graduate in Electronics are

- **Disciplinary knowledge**

(i) comprehensive knowledge and understanding of major concepts, theoretical principles and experimental developments in Electronics and its different subfields like Analog Electronics, Digital Electronics, Network Analysis, VLSI technology, Communication Electronics, Microprocessor and Microcontrollers, Semiconductor Devices, Instrumentation, Digital Signal Processing, Verilog and FPGA Design, Photonic Devices, Power Electronics, Antenna Theory, wireless Network and other related fields of study, including broader interdisciplinary subfields like Physics, Chemistry, Mathematics, Life sciences, Environmental sciences, Computer science, Information Technology etc..

(ii) ability to use Electronics laboratory skills and modern instrumentation for designing and implementing new circuits and smart systems in Electronics, interdisciplinary/multidisciplinary research areas and industrial research.

- **Skilled communicator:** Ability to transmit abstract concepts and complex information relating to all areas in Electronics in a clear and concise manner through scientific report writing. Ability to express complex relationships and information through graphical methods, circuit diagrams and proper tabulation. Ability to explain complex processes through simulation and modelling. Ability to express complex and technical concepts orally in a simple, precise and straightforward language for better understanding.

- **Critical thinking:** Ability to distinguish between relevant and irrelevant facts and information, discriminate between objective and biased information, apply logic to arrive at definitive conclusions, find out if conclusions are based upon sufficient evidence, derive correct quantitative results, make rational evaluations, and arrive at qualitative judgments according to established rules.
- **Sense of inquiry:** Capability for asking relevant/appropriate questions relating to the issues and problems in the field of Electronics. Planning, executing and reporting the results of ~~a~~ theoretical or experimental investigation.
- **Team player/worker**: Capable of working effectively in diverse teams in both classroom, laboratory, Electronics workshop and in field-based situation.
- **Skilled project manager:** Capable of identifying/mobilizing appropriate resources required for a project, and managing a project through to completion, while observing responsible and ethical scientific conduct, safety and laboratory hygiene regulations and practices.
- **Digitally Efficient*:*** Capable of using computers for computational and simulation studies in Electronics. Proficiency in appropriate software for numerical and statistical analysis of data, accessing and using modern e-library search tools, ability to locate, retrieve, and evaluate Electronics information from renowned archives, proficiency in accessing observational and experimental data made available by renowned research labs for further analysis. Excellence in development of smart system and efficient control circuits using suitable electronic components and microcontrollers.
- **Ethical awareness/analytical reasoning*:*** The graduates should be capable of demonstrating the ability to think and analyze rationally with modern and scientific outlook and adopt objectives, which are unbiased and truthful in all aspects of their work. They should be capable of ~~i~~identifying ethical issues related to their work. They should be ready to appropriately acknowledge direct and indirect contributions received from all sources, including from other personnels in their field. They should be willing to contribute to the free development of knowledge in all forms. Further, unethical behavior such as fabrication, falsification or misrepresentation of data, or committing plagiarism, or not adhering to intellectual property rights should be avoided.
- **Social, National and International perspective*:*** The graduates should be able to develop a perspective about the significance of their knowledge and skills for social well-being and a sense of responsibility towards human society and the planet. They should have a national as well as an international perspective for their work and career in the chosen field of academic and research activities.
- **Lifelong learners:** Capable of self-paced and self-directed learning aimed at personal development and for improving knowledge/skill development and re-skilling in all areas of Electronics.

4. QUALIFICATION DESCRIPTORS FOR GRADUATES IN B.Sc. PHYSICAL SCIENCES WITH ELECTRONICS DISCIPLINE

The qualification descriptors for a B.Sc. Physical science program with Electronics discipline (with combinations of Physics, Electronics and Mathematics (PEM)) should include the following:

The graduates should be able to

- Demonstrate:

(i) a systematic and coherent understanding of basic Electronics including the concepts, theories and relevant experimental techniques in the domains of Network Analysis, Analog Electronics, Digital Electronics, Integrated Circuits, Communication Electronics, Microprocessor, Microcontroller and of the specialized field like Semiconductor Devices, Electronic Instrumentation, Digital Signal Processing, Verilog and FPGA Design, Photonic Devices, Power Electronics, Antenna Theory, wireless Network, etc. in their choice of Discipline Specific Elective course.

(ii) ability to relate their understanding of Electronics to other subjects like Physics, or Mathematics, which are part of their curriculum, and hence orient their knowledge and work towards multi-disciplinary/inter-disciplinary contexts and problems.

(iii) procedural knowledge that creates different types of professionals related to different areas of study in Electronics and multi/interdisciplinary domains, including research and development, teaching, technology professions, and government and public service.

(iv) skills in areas of specializations of their elected subfields, so that they can continue with higher studies and can relate their knowledge to current developments in those subfields.

- Use knowledge, understanding and skills required for identifying problems and issues relating to Electronics, and its interface with other subjects studied in the course, collect relevant quantitative and/or qualitative data/circuits from a wide range of sources including various research laboratories of the world, their application, and do analysis and evaluation using appropriate methodologies.
- Communicate the results of studies undertaken accurately in a range of different contexts using the main concepts, constructs and techniques of Electronics and other subjects studied in the course. Develop communication abilities to present these results in technical as well as popular science meetings.
- Ability to meet their own learning needs, drawing on a range of pedagogic material available on the internet and books, current research and development work and professional materials, and in interaction with other science professionals.
- Apply their knowledge of Electronics (theoretical and laboratory skills) to new/ unfamiliar contexts. To identify and analyze problems and issues, solve complex problems in Electronics and its interface with other subjects.
- Demonstrate Electronics-related technological skills that are relevant to employment in industry and elsewhere.

5. PROGRAM LEARNING OUTCOMES IN B.Sc. PHYSICAL SCIENCES WITH ELECTRONICS DISCIPLINE (B.SC. (PEM))

The student graduating with the Degree B.Sc. Physical sciences with Electronics discipline, B.Sc. (PEM) should be able to

- Acquire

(i) a systematic and coherent understanding of basic Electronics including the concepts, theories and relevant experimental techniques in the domains of Network Analysis, Analog Electronics, Digital Electronics, Integrated Circuits, Communication Electronics, Microprocessor, Microcontroller and of the specialized field like Semiconductor Devices, Electronic Instrumentation, Digital Signal Processing, Verilog and FPGA Design, Photonic Devices, Power Electronics, Antenna Theory, wireless Network, etc. in their choice of Discipline Specific Elective course.

(ii) a wide ranging and comprehensive experience in Electronics laboratory methods in experiments related to Network Analysis, Analog Electronics, Digital Electronics, Communication, Microcontroller, Semiconductor Devices, Instrumentation, Digital Signal Processing, Verilog and FPGA, Antenna's, etc. Students acquire the ability for systematic designing and analysis of circuits, recording of proper observations, use of scientific research instruments, analysis of observational data, making suitable error estimates and scientific report writing.

(iii) procedural knowledge that creates different types of professionals related to the disciplinary/subject area of Electronics and multi/interdisciplinary domains, including professionals engaged in research and development, teaching, technology professions and government/public service;

(iv) skills in areas related to their specialization area within the disciplinary/subject area of Electronics.

- Demonstrate the ability to use skills in Electronics and its related areas of technology for formulating and solving problems and identifying and applying appropriate physical principles and methodologies to solve a wide range of problems associated with Electronics and its interface with other subjects studied in the course.
- Recognize the importance of modeling simulation and computing, and the role of approximation and mathematical approaches to describing the Electronic world.
- Plan and execute experiments or investigations related to Electronics and its interface with other subjects studied in the course analyze and interpret data/information collected using appropriate methods, including the use of appropriate software such as programming languages and purpose-written packages, and report accurately the findings of the experiment/investigations while relating the conclusions/findings to relevant theories.
- Demonstrate relevant generic skills and global competencies such as

(i) problem-solving skills that are required to solve different types of Electronics-related problems with well-defined solutions, and tackle open-ended problems that belong to the disciplinary area boundaries;

(ii) investigative skills, including skills of independent investigation of problems;

(iii) communication skills involving the ability to listen carefully, to read texts and research papers analytically and to present complex information in a concise manner to different groups/audiences of technical or popular nature;

(iv) analytical skills involving paying attention to detail and ability to construct logical arguments, using correct technical language and ability to translate them with popular language when needed;
(v) ICT skills;
(vi) personal skills such as the ability to work both independently and in a group.

- Demonstrate professional behavior such as

(i) being objective, unbiased and truthful in all aspects of work and avoiding unethical, irrational behavior 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 its universal appeal for the entire humanity;
(iv) appreciation of intellectual property, environmental and sustainability issues; and
(v) promoting safe learning and working environment.

6. TEACHING LEARNING PROCESSES

The teaching learning processes play the most important role in achieving the desired aims and objectives of the undergraduate B.Sc. Physical Science program in Electronics (PEM). The LOCF framework emphasizes learning outcomes for every Electronics course and its parts. This helps in identifying most suitable teaching learning processes for every segment of the curricula. Electronics is basically an experimental science with a very elaborate and advanced applied structure. Systematic observations of controlled experiments open up windows to hidden properties and unexplored circuits and devices. Physics concepts and theories are meant to create a systematic understanding of the properties and laws used in Electronics. All principles and laws of Physics are accepted only after their verifications and confirmations in laboratory, or observations in the real world, which require scientists trained in appropriate experimental techniques, and engineers to design and make advanced scientific instruments and smart systems. Electronics graduates need a deep understanding of applied concepts, principles and theories of Physics, which help in gaining familiarity with different branches of Electronics. To achieve these goals, the appropriate training of young individuals to become competent scientists, researchers and engineers in future have to be accomplished. For this purpose, a very good undergraduate program, B.Sc. Physical Science in Electronics is required as a first step. An appropriate teaching-learning procedural protocol for all the colleges is therefore essential. To be specific, it is desirable to have:

- Sufficient number of teachers in permanent position to do all the class room teaching and supervise the laboratory experiments to be performed by the students.
- All teachers should be qualified as per the UGC norms and should have good communication skills.
- Sufficient number of technical and other support staff to run the laboratories, libraries, equipment and maintain the infrastructural facilities like buildings, ICT infrastructure, electricity, sanitation, etc.
- Necessary and sufficient infrastructural facilities for the class rooms, laboratories and libraries.
- Modern and updated laboratory equipment needed for the undergraduate laboratories and reference and text books for the libraries.

- Sufficient infrastructure for ICT and other facilities needed for technology-enabled learning like computer facilities, PCs, laptops, Wi-Fi and internet facilities with all the necessary software.

Teachers should make use of all the approaches for an efficient teaching-learning process i.e.:

(i) Class room teachings with lectures using traditional as well as electronic boards.
(ii) Use of Smart class rooms for simulation and demonstration for conveying the difficult concepts of Physics in class room teaching and laboratories.
(iii) Demonstration of the required experiments in laboratory and workshops on necessary apparatuses, data analysis, error estimation and scientific report writing for effective and efficient learning of laboratory techniques.
(iv) Imparting the problem solving ability which enables a student to apply physical and mathematical concepts to a new and concrete situation is essential to all courses. This can be accomplished through examples discussed in the class or laboratory, assignments and tutorials.
(v) CBCS curriculum has introduced a significant content of computational courses. Computational physics should be used as a new element in the electronics pedagogy, and efforts should be made to introduce computational problems, including simulation and modelling, in all courses.
(vi) Teaching should be complimented with students seminar to be organized very frequently.
(vii) Guest lectures and seminars should be arranged by inviting eminent teachers, and scientists.
(viii) Open-ended project work should be given to all students individually, or in group to 2-3 students depending upon the nature of the course.
(ix) Since actual undergraduate teaching is done in affiliated colleges which have differing levels of infrastructure and student requirements, the teachers should attend workshops organized by the University Department for college faculty on teaching methodology, reference materials, latest laboratory equipment and experiments, and computational physics software for achieving uniform standards. Common guidelines for individual courses need to be followed/evolved.
(x) Internship of duration varying from one week anytime in the semester, and/or 2-6 weeks during semester break and summer breaks should be arranged by the college for the students to visit other colleges/universities/HEI and industrial organizations in the vicinity. If needed, financial assistance may also be provided for such arrangements
(xi) Special attempts should be made to develop problem-solving skills and design of laboratory experiments for demonstration. For this purpose, a mentor system may be evolved where 3-4 students may be assigned to each faculty member.
(xii) Teaching load should be managed such that the teachers have enough time to interact with the students to encourage an interactive/participative learning.

In the first year students are fresh from school. Given the diversity of their backgrounds, and the lack of adequate infrastructure and training in science learning in many schools, special care and teacher attention is essential in the first year. Mentorship with senior students and teachers can help them ease into rigors of university level undergraduate learning.

A student completing the Physical Sciences with Electronics discipline course under the CBCS takes 4 core courses in each discipline, 2 discipline specific electives (DSE) courses in each discipline, 4 skill enhancement courses (SEC) including at least one from each discipline and two ability enhancement compulsory courses (AECC). Since different categories of courses have different objectives and intended learning outcomes, the most efficient and appropriate teaching learning processes would not be same for all categories of courses.

6.1 TEACHING LEARNING PROCESSES FOR CORE COURSES

The objective of Core courses is to build a comprehensive foundation of physics concepts, principles and laboratory skills so that a student is able to proceed to any specialized branch within Electronics. Rather than a quantitative amalgamation of disparate knowledge, it is much more preferable that students gain the depth of understanding and ability to apply what they have learnt to diverse problems.

All Core courses have a theory and an associated Electronics laboratory component. Even though the learning in theory and lab components proceeds in step, the teaching learning processes for the two components need specific and different emphases.

6.1.1 Teaching Learning Processes for Theory component of Core Courses

A significant part of the theoretical learning in core courses is done in the traditional lecture cum black-board method. Demonstrations with models, power-point projection, student project presentations, etc. are some other methods which should be judiciously used to enhance the learning experience. Problem solving should be integrated into theoretical learning of core courses and proportionally more time should be spent on it. It is advisable that a list of problems is distributed to students before the discussion of every topic, and they are encouraged to solve these in the self-learning mode, since teachers are unlikely to get time to discuss all of them in the class room.

6.1.2 Teaching Learning Processes for Electronics Laboratory component of Core Courses

Students learn essential Electronics laboratory skills mainly while preparing for experiments, performing them in the laboratory, and writing appropriate laboratory reports. Most of this learning takes place in the self-learning mode. However, teachers' role is crucial at critical key points. Electronics laboratory learning suffers seriously if students do not get appropriate guidance at these key points. Many students get their first proper exposure to Electronics laboratory work in their first year of undergraduate studies. Hence, laboratory teaching to first year students requires special care.

Demonstration on the working of required apparatuses should be given in few beginning laboratory sessions of all courses. Sessions on the essentials of experimental data analysis, error estimation, and scientific report writing are crucial in the first year physics laboratory teaching. Once the essentials have been learnt, sessions may be taken on applications of these for specific experiments in lab courses of later years. Students should be encouraged to explore experimental physics projects outside the curricula.

Many college laboratories lack latest laboratory equipment due to resource crunch. For example very few laboratories have equipment for sensor and microprocessor based data acquisition, whose output can be directly fed into a computer for further analysis. Colleges need to make strategic planning, including student participation under teacher guided projects, to gradually get their laboratories equipped with latest equipment. The Department of the Physics and Astrophysics of the University can provide key guidance and help in this regard.

It is recommended that the maximum size of group for all Physics Laboratory courses should be 12-15 students.

6.2 TEACHING LEARNING PROCESSES FOR DISCIPLINE SPECIFIC ELECTIVES

The objective of DSE papers is to expose students to domain specific branches of Electronics and prepare them for further studies in the chosen field. While students must learn basic theoretical concepts and principles of the chosen domain, a sufficient width of exposure to diverse topics is essential in these papers. Student seminars and projects can be a very fruitful way to introduce students to the latest research level developments.

Besides a theory component, every DSE paper has either an associated tutorial, or a Electronics laboratory. Teaching learning processes for theory and Electronics laboratory components described above in sub-sections 6.1.1and 6.1.2 for core courses, should be applicable for DSE courses too.

Tutorials provide an opportunity for attending closely to learning issues with individual students, and hence an effective means to help create interest in the subject and assess their understanding. Pre-assigned weekly problem sets and assignments help structure tutorial sessions and should be used as often as possible. Students' performance in tutorials should be used for determining their internal assessment marks for the course.

It is recommended that the maximum size of group in a tutorial should be 8-10 students per group.

6.3 TEACHING LEARNING PROCESSES FOR SKILL ENHANCEMENT COURSES

Skill Enhancement papers are intended to help students develop skills which may or may not be directly applicable to Electronics learning. These courses introduce an element of diversity of learning environments and expectations. Efforts should be made that students gain adequate 'hands-on' experience in the desired skills. The theory parts of these courses are intended to help students get prepared for such experiences. Since the assessment of these courses is largely college based, teachers should make full use of it to design novel projects.

At the end, the main purpose of Electronics teaching should be to impart higher level objective knowledge to students in concrete, comprehensive and effective ways. Here, effectiveness implies gaining knowledge and skill which can be applied to solve practical problems as well as attaining the capability of logical thinking and imagination which are necessary for the creation of new knowledge and new discoveries. Once the students understand 'why is it worth learning?' and 'how does it connect to the real world?', they will embrace the curriculum in a way that would spark their imagination and instill a spirit of enquiry in them, so that in future they can opt for further investigations or research. All in all, the teacher should act as a facilitator and guide and not as a guardian of the curriculum.

It is recommended that the maximum size of group in the Laboratory for SEC courses should be 12-15 students per group.

7. ASSESSMENT METHODS

In the undergraduate education leading to the B.Sc. Physical Science degree with Electronics, the assessment and evaluation methods should focus on testing the conceptual understanding of basic concepts and theories, experimental techniques, development of mathematical skills, and the ability to apply the knowledge acquired to solve new problems and communicate the results and findings effectively.

The two perennial shortfalls of the traditional science examination process in our country are the reliance on rote learning for written exams, and a very perfunctory evaluation of laboratory skills. Greater emphasis on problem solving and less importance to textbook derivations discourages rote learning. Theory examinations should be based primarily on unseen problems. Continuous evaluation of students' work in the laboratory, and testing them on extensions of experiments they have already performed can give a more faithful evaluation of their laboratory skills.

Needless to say, there should be a continuous evaluation system for students. This will enable teachers not only to ascertain the overall progress of learning by the students, but also to identify students who are slow learners and for whom special care should be taken. An appropriate grading system is the 'relative grading system'. It introduces a competitive element among students, but does not excessively penalizes weaker students.

Since the Learning Objectives are defined clearly for each course in the LOCF framework, it is easier to design methods to monitor the progress in achieving the learning objectives during the course and test the level of achievement at the end of the course.

Formative Assessment for monitoring the progress towards achieving the learning objectives is an important assessment component, which provides both teachers and students feedback on progress towards learning goals. University of Delhi examination system has 20 percent internal assessment for theory component, and 50 percent for physics laboratory and computational physics laboratory components. These marks should be distributed in periodic assessments in different modes to serve the intended purpose

Since core courses, discipline specific courses and skill enhancement courses have qualitatively different kinds of objectives and learning outcomes, one model of assessment methods will not work for these different kinds of courses.

7.1 ASSESSMENT METHODS FOR CORE COURSES

Core courses and associated Electronics laboratory curricula lead to the essential set of learning outcomes, which every Electronics graduate is expected to have. Their assessment methods require rigour, comprehensiveness and uniformity about what is minimally expected from students. Regular interactions mediated through university department among teachers teaching these courses in different colleges may prove to be helpful in this regard. Since depth of understanding of core topics is a highly desirable outcome, assessment for these courses should put greater emphasis on unseen problems, including extensions of textbook derivations done in class.

7.1.1 Assessment Methods for the Theory component of Core courses

The evaluation scheme of the University of Delhi allots 20 percent marks for internal assessment of theory papers. Teachers should use a judicious combination of the following methods to assess students for these marks: i) periodic class tests, ii) regular problem based assignments, iii) unannounced short quizzes, iv) individual seminar presentations v) longer assignments for covering theory and derivations not discussed in regular lectures, vi) True/False Tests, and vii) Multiple Choice Tests for large classes.

To help students prepare themselves for formative assessment during the semester, and to motivate them for self-learning, it is advisable that a Model Problem Set is made available to them in the beginning of the course, or problem sets are given before discussion of specific topics in class.

In preparing students for Substantive Summative Assessment at the end of the semester it is helpful if a Model/mock question paper is made available to them in the beginning of the course.

7.1.2 Assessment Methods for the Electronics Laboratory component of Core courses

The 50 percent internal assessment for the evaluation scheme for laboratory courses is best used in continuous evaluation of students' performance in the lab. This evaluation should include these components: i) Regular evaluation of experiments regarding a) written report of each experiment and b) Viva-Voce on each experiment, ii) Test through setting experiments by assembling components, iii) written test on experiments done in the lab and data analysis, iv) Designing innovative kits to test the comprehension and analysis of the experiment done by the students, and v) audio visual recording of the experiments being performed by students and its self-appraisal.

The end semester laboratory examination should ideally involve extensions of experiments done by students during the semester. Two or more experiments can be combined for this purpose. Open ended problems for which students can get the answer by designing their own experimental method should also be tried.

7.2 ASSESSMENT METHODS FOR DISCIPLINE SPECIFIC ELECTIVES

Discipline specific courses build upon general principles learnt in core courses, and also prepare students for further studies in specific domains of Electronics. Given the time constraint of only one semester, specific domain exposure is mostly introductory in character. Assessment for these courses should have significant component of open-ended methods like seminars and project work. Students have greater chance of proving their individual initiative and ability for self-learning in these methods. These methods also have greater flexibility to reward students for out of curriculum learning.

Besides a theory component, every DSE paper has either an associated tutorial, or a Electronics laboratory, or a computational physics component. Assessment methods for theory and Electronics laboratory components described above in sub-sections 7.1.1 and 7.1.2 for core courses, should be applicable for DSE courses too.

Students should be assessed for their performance in **tutorials**, and this assessment should contribute to their internal assessment marks. Their work on pre-assigned problem sets/assignments, and participation in tutorial discussions should be taken into account while assessing their performance.

7.3 ASSESSMENT METHODS FOR SKILL ENHANCEMENT COURSES

Learning in skill enhancement courses is largely experience based. Student performance in these courses is best assessed under continuous evaluation. Students could be assigned a specific task for a class or group of classes, and they could be assessed for their success in meeting the task.

8. STRUCTURE OF COURSES IN B.Sc. PHYSICAL SCIENCES (PEM) WITH ELECTRONICS DISCIPLINE

8.1 CREDIT DISTRIBUTION FOR B.SC. PHYSICAL SCIENCES (WITH PEM).

The B.Sc. Physical science (PEM) programme with Electronics as one of the Discipline consists of 132 credits based on the Choice Based Credit System (CBCS) approved by the UGC with 01 hour/week for each credit for theory/tutorials and 02 hours/week for each credit of laboratory work/Hands-on exercises. Out of 132 credits, 108 credits are of core and DSE courses equally divided between Electronics discipline, Physics Discipline and Mathematics Discipline (36 credits each), 16 credits consist of Skilled Enhancement courses (SEC) which are elective and 8 credits consists of Ability Enhancement Compulsory Courses (AECC) equally divided (4 credits each) between disciplines of the Environmental sciences and Languages/communications. A student can take more than 132 credits in total (but not more than 148 credits) to qualify for the grant of the B.Sc. Physical Sciences degree as per rules and regulations of the University.

Table 8.1 Table showing distribution of credits: Subject-A: Physics Discipline, Subject-B: Electronics Discipline, and Subject-C: Mathematics Discipline

Semester	**Compulsory Core Courses (CC) each with 06 credit (Total no. of Papers 12) 04 Core courses are compulsory to be from each subject A, B and C**	**Discipline Specific Elective (DSE) each with 06 credits, Select any 02 courses from each subject A, B and C**	**Ability Enhancement Compulsory Courses (AECC) each with 04 credits, Select any 02 from 03 courses**	**Skill Enhancement Course (SEC) each with 04 credits. Select any 04 Courses. Select at least 1 from each subject A, B and C**	**Total Credits**
Sem I	CC-1A CC-1B CC-1C	-	AECC-1	-	22
Sem II	CC-2A CC-2B CC-2C	-	AECC-2	-	22
Sem III	CC-3A CC-3B CC-3C	-	-	SEC-1(A/B/C)	22
Sem IV	CC-4A CC-4B CC-4C	-	-	SEC-2(A/B/C)	22
Sem V	-	DSE-1A DSE -1B DSE -1C	-	SEC-3(A/B/C)	22
Sem VI	-	DSE -2A DSE -2B DSE -2C	-	SEC-4(A/B/C)	22
Total Credits	**72**	**36**	**8**		**132**

Table 8.2 DETAILS OF COURSES UNDER UNDERGRADUATE PROGRAMME (B.Sc. Physical Science-PEM)

Course | **#Credits**
Theory + Practical/Tutorials

==

I. Core Course 12 X (4+2)* = 72
(12 Papers)

04 Courses from each of the

03 disciplines of choice

II. DSE Courses 6 X (4+2)* or 6 X (5+1)** =36

(6 Papers)

Two papers from each discipline (Physics, Electronics, Mathematics) of choice.

Optional Dissertation or project work in place of one Discipline elective paper (6 credits) in 6th Semester

III. AECC Courses 2 X 4 = 8

(2 Papers of 4 credits each) Environmental Science English/MIL Communication

IV. SEC Courses 4 X (2+2)* =16

(4 Papers of 4 credits each)

Total credit = 132

College should evolve a system/policy about ECA/Interest/Hobby/ Sports/NCC/ NSS/related courses on its own.
***Theory with practical/ Hands-on Exercise**
****Theory with tutorials**
#wherever there is practical there will be no tutorials and vice -versa.
#The size of group for practical papers is recommended to be maximum of 12 to 15 students and for tutorials 8-10 students per group.

8.2 SEMESTER-WISE DISTRIBUTION OF COURSES

CORE COURSES (CC)

Table 8.3 All CC courses of Electronics Discipline have 6 credits with 4 credits of theory and 2 credits of practical. Subject B: Electronics Discipline

Core Course type	Unique Paper Code	Semester	Core papers (Subject B: Electronics Discipline)
CC-1B	42511101	I	Network Analysis and Analog Electronics + Lab
CC-2B	42511201	II	Linear and Digital Integrated Circuits + Lab
CC-3B	42514305	III	Communication Electronics + Lab
CC-4B	42514413	IV	Microprocessor and Microcontroller + Lab

DISCIPLINE SPECIFIC ELECTIVES (DSE)

Table 8.4 All DSE courses of Electronic Disciplines (Subject- B) have 06 credits with 04 credits of theory and 02 credits of practical or 05 credits of theory and 01 credit of Tutorial.

Discipline Specific (Subject-B: Electronics) Elective papers (Credit: 06 each) (DSE 1B, DSE 2B): Select any 02 papers (one for each semester-V and semester-VI) from the following options **(numbers in brackets indicate number of hours/Week dedicated)**

S.No.	**Unique Paper Code**	**DSE papers (Subject B: Electronics Discipline)**
	Odd Semester – V Semester only (DSE-1B)	
1	42517511	Semiconductor Devices Fabrication (4) + Lab (4)
2	42517512	Electronic Instrumentation (4) + Lab (4)
3	42517513	Digital Signal Processing (4) + Lab (4)
	Even Semester – VI semester only (DSE-2B)	
4	42517614	Verilog and FPGA based system Design (4) + Lab (4)
5	42517615	Photonic Devices and Power Electronics (4) + Lab (4)
6	42517616	Antenna Theory and wireless Network (5) + Tut (1)
7	42517617	Dissertation

SKILL ENHANCEMENT COURSES (SEC)

Table 8.5 All SEC* courses of Electronic Discipline (Subject-B) have 04 credits with 02 credits of theory and 02 credits of Practical/Tutorials/Projects and Field Work to be decided by the College.

<u>Teachers may give a long duration project based on this paper.</u>

S.No.	Unique Paper Code	Semester	SEC papers* (Subject B: Electronics Discipline)
1	32223902	III/IV/V/VI	Computational Physics Skills
2	32223903	III/IV/V/VI	Electrical Circuit and Network skills
3	32223905	III/IV/V/VI	Renewable Energy and Energy Harvesting
4	32223906	III/IV/V/VI	Engineering design and prototyping/Technical Drawing
5	32223908	III/IV/V/VI	Applied Optics
6	32223909	III/IV/V/VI	Weather Forecasting
7	XXX1	III/IV/V/VI	Introduction to Physical Computing
8	XXX2	III/IV/V/VI	Numerical Analysis

* **Students pursuing B.Sc. Physical science with PEM (Physics, Electronics and Mathematics) combination should select the SEC papers related to Electronics Discipline (from Table 8.5) carefully. SEC papers are common for both Physics and Electronics Disciplines. Student should select different SEC papers in all semesters (III/IV/V and VI) for both disciplines (Subject-A and Subject-B). Same two papers of SEC to qualify B.Sc. degree is not allowed.**

ABILITY ENHANCEMENT COMPULSORY COURSES (AECC)

Table 8.6 All the courses have 4 credits. The detailed content of these courses is NOT mentioned in this document.

AECCC	B.Sc. Physical Science (PEM)
1	English
2	MIL Communications
3	Environment Science

TABLE 8.7 SEMESTER-WISE BREAKUP OF TYPES OF COURSES WITH THEIR CREDITS. Subject-A: Physics Discipline, Subject-B: Electronics Discipline, and Subject-C: Mathematics Discipline.

Sem	Course opted	Course name	Credits
I	Ability Enhancement Compulsory Course-I	English communications/ Environmental Science	4
	Core Course-1A	CC-1A	6
	Core Course-1B	Network Analysis and Analog Electronics (Theory + Lab)	4 + 2
	Core Course-1C	CC-1C	6
II	Ability Enhancement Compulsory Course-II	English communications/ Environmental Science	4
	Core Course-2A	CC-2A	6
	Core Course-2B	Linear and Digital Integrated Circuits (Theory + Lab)	4 + 2
	Core Course-2C	CC-2C	6
III	Core Course-3A	CC-3A	6
	Core Course-3B	Communication Electronics (Theory + Lab)	4 + 2
	Core Course-3C	CC-3C	6
	Skill Enhancement Course -1	SEC-1 (A/B/C)	4

IV	Core Course-4A	CC-4A	6
	Core Course-4B	Microprocessor and Microcontroller (Theory + Lab)	4 + 2
	Core Course-4C	CC-4C	6
	Skill Enhancement Course -2	SEC-2 (A/B/C)	4
V	Discipline Specific Elective -1 A	DSE-1A (Subject A: Physics)	6
	Discipline Specific Elective -1 B	DSE-1B (Subject B: Electronics) See Table 8.4	6
	Discipline Specific Elective -1 C	DSE-1C (Subject C: Mathematics)	6
	Skill Enhancement Course -3	SEC-3 (A/B/C)	4
VI	Discipline Specific Elective - 2 A	DSE-1A (Subject A: Physics)	6
	Discipline Specific Elective - 2 B	DSE-1B (Subject B: Electronics) See Table 8.4	6
	Discipline Specific Elective - 2 C	DSE-1C (Subject C: Mathematics)	6
	Skill Enhancement Course – 4	SEC-4 (A/B/C)	4
		TOTAL	**132**

9. DETAILED COURSES FOR PROGRAMME IN B.SC. PHYSICAL SCIENCES, INCLUDING COURSE OBJECTIVES, LEARNING OUTCOMES, AND READINGS

9.1. CORE COURSES

CC-1B: Network Analysis and Analog Electronics (42511101)
Credit: 06 (Theory-04, Practical-02)
Theory: 60 Hours
Practical: 60 Hours

Course Objective

- This course offers the basic knowledge to students to design and analyze the network circuit analysis and analog electronics.
- It gives the concept of voltage, current sources and various electrical network theorems. Physics of Semiconductor devices including Junction diode, Bipolar junction Transistors, Unipolar devices and their applications are discussed in detail.
- This also develops the understanding of amplifier and its applications.

Course Learning Outcomes

At the end of this course, students will be able to achieve the following learning outcomes:

- To understand the concept of voltage and current sources, Network theorems, Mesh and Node Analysis.
- To develop an understanding of the basic operation and characteristics of different type of diodes and familiarity with its working and applications.
- Become familiar with Half-wave, Full-wave center tapped and bridge rectifiers. To be able to calculate ripple factor and efficiency.
- To be able to recognize and explain the characteristics of a PNP or NPN transistor.
- Become familiar with the load-line analysis of the BJT configurations and understand the hybrid model (h- parameters) of the BJT transistors.
- To be able to perform small signal analysis of Amplifier and understand its classification.
- To be able to perform analysis of two stage R-C coupled Amplifier.
- To understand the concept of positive and negative feedback along with applications of each type of feedback and the working of Oscillators.
- To become familiar with construction, working and characteristics of JFET and UJT.

Unit 1

Circuit Analysis: Concept of Voltage and Current Sources. Kirchhoff's Current Law, Kirchhoff's Voltage Law. Mesh Analysis Node Analysis. Star and Delta networks, Star-Delta Conversion. Principal of Duality. Superposition Theorem. Thevenin's Theorem. Norton's Theorem. Reciprocity Theorem. Maximum Power Transfer Theorem. Two Port Networks: h, y and z parameters and their conversion.

(14 Lectures)

Unit 2

Junction Diode and its applications: PN junction diode (Ideal and practical)-constructions, Formation of Depletion Layer, Diode Equation and I-V characteristics. Idea of static and dynamic resistance, dc load line analysis, Quiescent (Q) point. Zener diode, Reverse saturation current, Zener and avalanche breakdown. Qualitative idea of Schottky diode. Rectifiers-Half wave rectifier, Full wave rectifiers (center tapped and bridge), circuit diagrams, working and waveforms, ripple factor and efficiency. Filter- Shunt capacitor filter, its role in power supply, output waveform, and working. Regulation- Line and load regulation, Zener diode as voltage regulator, and explanation for load and line regulation.

(18 Lectures)

Unit 3

Bipolar Junction Transistor: Review of the characteristics of transistor in CE and CB configurations, Regions of operation (active, cut off and saturation), Current gains α and β. Relations between α and β. dc load line and Q point.

(5 Lectures)

Amplifiers: Transistor biasing and Stabilization circuits- Fixed Bias and Voltage Divider Bias. Thermal runaway, stability and stability factor S. Transistor as a two port network, h-parameter equivalent circuit. Small signal analysis of single stage CE amplifier. Input and Output impedance, Current and Voltage gains. Class A, B and C Amplifiers.

(10 Lectures)

Unit 4

Cascaded Amplifiers: Two stage RC Coupled Amplifier and its Frequency Response.

(2 Lectures)

Feedback in Amplifiers: Concept of feedback, negative and positive feedback, advantages of negative feedback (Qualitative only).

(2 Lectures)

Sinusoidal Oscillators: Barkhausen criterion for sustained oscillations. Phase shift and Colpitt's oscillator. Determination of Frequency and Condition of oscillation.

(5 Lectures)

Unipolar Devices: JFET. Construction, working and I-V characteristics (output and transfer), Pinch-off voltage. UJT, basic construction, working, equivalent circuit and I-V characteristics.

(4 Lectures)

PRACTICAL (60 Hours)
ELECTRONICS LAB: CC-1B LAB: NETWORK ANALYSIS AND ANALOG ELECTRONICS LAB

"Sessions on the construction and use of specific measurement instruments and experimental apparatuses used in the lab, including necessary precautions.

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. Application to the specific experiments done in the lab."

At least 06 experiments from the following besides experiment no. 1:

1. To familiarize with basic electronic components (R, C, L, diodes, transistors), digital Multimeter, Function Generator and Oscilloscope.
2. Measurement of Amplitude, Frequency & Phase difference using Oscilloscope.
3. Verification of (a) Thevenin's theorem and (b) Norton's theorem.
4. Verification of (a) Superposition Theorem and (b) Reciprocity Theorem.
5. Verification of the Maximum Power Transfer Theorem.
6. Study of the I-V Characteristics of (a) p-n junction Diode, and (b) Zener diode.
7. Study of (a) Half wave rectifier and (b) Full wave rectifier (FWR).
8. Study the effect of (a) C- filter and (b) Zener regulator on the output of FWR.
9. Study of the I-V Characteristics of UJT and design relaxation oscillator.
10. Study of the output and transfer I-V characteristics of common source JFET.
11. Study of Fixed Bias and Voltage divider bias configuration for CE transistor.
12. Design of a Single Stage CE amplifier of given gain.
13. Study of the RC Phase Shift Oscillator.
14. Study the Colpitt's oscillator.

References for Theory:

Essential Readings

1. Network,Lines and Fields, J.D.Ryder, Prentice Hall of India.
2. Electronic Devices and Circuits, David A. Bell, 5th Edition 2015, Oxford University Press.
3. Electronic Circuits: Discrete and Integrated, D.L. Schilling and C. Belove, Tata McGraw Hill.
4. J. Millman and C. C. Halkias, Integrated Electronics, Tata McGraw Hill (2001)
5. Allen Mottershead, Electronic Devices and Circuits, Goodyear Publishing Corporation.

Additional Readings

1. Electric Circuits, S. A. Nasar, Schaum's outline series, Tata McGraw Hill (2004).
2. Electrical Circuits, K.A. Smith and R.E. Alley, 2014, Cambridge University Press.
3. Microelectronic circuits, A.S. Sedra, K.C. Smith, A.N. Chandorkar, 2014, 6th Edn., Oxford University Press.

References for Laboratory

1. Electrical Circuits, M. Nahvi & J. Edminister, Schaum's Outline Series, Tata McGraw-Hill (2005).
2. 2000 Solved Problems in Electronics, J. J. Cathey, Schaum's outline Series, Tata McGraw Hill (1991).
3. Basic Electronics: Principles and Applications, C.Saha, A.Halder, D.Ganguli, 2018, Cambridge University Press
4. Electronic Principles, A. Malvino, D.J. Bates, 7th Edition, 2018, Tata Mc-Graw Hill Education.

CC-2B: Linear and Digital Integrated Circuits (42511201)

Credit: 06 (Theory-04, Practical-02)
Theory: 60 Hours
Practical: 60 Hours

Course Objective

- This paper aims to provide the basic knowledge of linear and digital electronics.
- It discusses about the operational amplifier and its applications. It introduces the number systems such as Decimal, Binary, Octal and Hexadecimal number systems along with their applications in arithmetic circuits.
- Boolean algebra and combinational logic circuits are also discussed.

Course Learning Outcomes

At the end of this course, students will be able to achieve the following learning outcomes:

- To understand Op- Amp basics and its various applications.
- To become familiar with number systems and codes, Logic Gates, Boolean Algebra Theorems.
- To understand the minimization techniques for designing a simplified logic circuit.
- To design a half Adder, Full Adder, Half-Subtractor, Full-Subtractor.
- To understand the working of Data processing circuits Multiplexers, Demultiplexers, Decoders, Encoders.
- To become familiar with the working of flip-flop circuits, its working and applications.

Unit 1

Operational Amplifiers (Black box approach): Characteristics of an Ideal and Practical Operational Amplifier (IC 741), Open and closed loop configuration, Frequency Response. CMRR. Slew Rate and concept of Virtual Ground.

(5 Lectures)

Applications of Op-Amps: (1) Inverting and non-inverting amplifiers, (2) Summing and Difference Amplifier, (3) Differentiator, (4) Integrator, (5) Wein bridge oscillator, (6) Comparator and Zero-crossing detector, and (7) Active low pass and high pass Butter worth filter (1st order only).

(12 Lectures)

Unit 2

Number System and Codes: Decimal, Binary, Octal and Hexadecimal number systems, base conversions. Representation of signed and unsigned numbers, BCD code. Binary, octal and hexadecimal arithmetic; addition, subtraction by 2's complement method, multiplication.

(9 Lectures)

Unit 3

Logic Gates and Boolean algebra: Truth Tables of OR, AND, NOT, NOR, NAND, XOR, XNOR, Universal Gates, Basic postulates and fundamental theorems of Boolean algebra.

(4 Lectures)

Combinational Logic Analysis and Design: Standard representation of logic functions (SOP and POS), Minimization Techniques (Karnaugh map minimization up to 4 variables for SOP).

(5 Lectures)

Unit 4

Arithmetic Circuits: Binary Addition. Half and Full Adder. Half and Full Subtractor, 4-bit binary Adder/Subtractor.

(5 Lectures)

Data processing circuits: Multiplexers, De-multiplexers, Decoders, Encoders.

(4 Lectures)

Unit 5

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. Master-slave JK Flip-Flop.

(6 Lectures)

Shift registers: Serial-in-Serial-out, Serial-in-Parallel-out, Parallel-in-Serial-out and Parallel-in-Parallel-out Shift Registers (only up to 4 bits).

(2 Lectures)

Unit 6

Counters (4 bits): Ring Counter. Asynchronous counters, Decade Counter. Synchronous Counter.

(4 Lectures)

D-A and A-D Conversion: 4 bit binary weighted and R-2R D-A converters, circuit and working. Accuracy and Resolution. A-D conversion characteristics, successive approximation ADC. (Mention of relevant ICs for all).

(4 Lectures)

PRACTICAL (60 Hours)
ELECTRONICS LAB: CC-2B LAB: LINEAR AND DIGITAL INTEGRATED CIRCUITS LAB

"Sessions on the construction and use of specific measurement instruments and experimental apparatuses used in the lab, including necessary precautions.

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. Application to the specific experiments done in the lab."

At least 04 experiments each from section A, B and C

Section-A: Op-Amp.Circuits (Hardware design)

1. To design an inverting amplifier using Op-amp (741,351) for dc voltage of given gain.
2. (a) To design inverting amplifier using Op-amp (741,351) and study its frequency response.
   (b) To design non-inverting amplifier using Op-amp (741,351) and study frequency response.

3. (a) To add two dc voltages using Op-Amp in inverting and non-inverting mode.
   (b) To study the zero-crossing detector and comparator.
4. To design a precision Differential amplifier of given I/O specification using Op-Amplifier.
5. To investigate the use of an op-amp as an Integrator.
6. To investigate the use of an op-amp as a Differentiator.
7. To design a Wien bridge oscillator for given frequency using an Op-Amplifier.
8. To design a circuit to simulate the solution of simultaneous equation and 1st/2nd order differential equation.
9. Design a Butter-worth Low Pass active Filter (1st order) and study frequency response.
10. Design a Butter-worth High Pass active Filter (1st order) and study frequency response.
11. Design a digital to analog converter (DAC) of given specifications.

Section-B: Digital circuits (Hardware design)

1. (a) To design a combinational logic system for a specified Truth Table.
   (b) To convert Boolean expression into logic circuit & design it using logic gate ICs.
   (c) To minimize a given logic circuit.
2. Half Adder and Full Adder.
3. Half Subtractor and Full Subtractor.
4. 4 bit binary adder and adder-subtractor using Full adder IC.
5. To design a seven segment decoder.
6. To build Flip-Flop (RS, Clocked RS, D-type and JK) circuits using NAND gates.
7. To build JK Master-slave flip-flop using Flip-Flop ICs.
8. To build a Counter using D-type/JK Flip-Flop ICs and study timing diagram.
9. To make a Shift Register (serial-in and serial-out) using D-type/JK Flip-Flop ICs.

Section-C: SPICE/MULTISIM simulations for electronic circuits and devices

1. To verify the Thevenin and Norton Theorems.
2. Design and analyze the series and parallel LCR circuits.
3. Design the inverting and non-inverting amplifier using an Op-Amp of given gain.
4. Design and Verification of op-amp as integrator and differentiator.
5. Design the 1st order active low pass and high pass filters of given cutoff frequency.
6. Design a Wein`s Bridge oscillator of given frequency.
7. Design clocked SR and JK Flip-Flop`s using NAND Gates.
8. Design 4-bit asynchronous counter using Flip-Flop ICs.
9. Design the CE amplifier of a given gain and its frequency response.

References for Theory

Essential Readings

1. OP-Amps and Linear Integrated Circuit, R.A. Gayakwad, 4th edition, 2000, Prentice Hall
2. Operational Amplifiers and Linear ICs, David A. Bell, 3rd Edition, 2011, Oxford University Press.
3. Digital Principles and Applications, A.P. Malvino, D.P.Leach and Saha, 8th Ed., 2018, Tata McGraw
4. Digital Circuits and systems, Venugopal, 2011, Tata McGraw Hill.

5. Thomas L. Flyod, Digital Fundamentals, Pearson Education Asia (1994).
6. Digital Principles, R.L.Tokheim, Schaum's outline series, Tata McGraw- Hill (1994).

References for Laboratory

1. Fundamentals of Digital Circuits, Anand Kumar, 4th Edn, 2018, PHI Learning.
2. Digital Computer Electronics, A.P. Malvino, J.A. Brown, 3rd Edition, 2018, Tata McGraw Hill Education.
3. Digital Electronics, S.K. Mandal, 2010, 1st edition, Tata McGraw Hill.

CC-3B : Communication Electronics (42514305)
Credit: 06 (Theory-04, Practical-02)
Theory: 60 Hours
Practical: 60 Hours

Course Objective

- This paper aims to describe the concepts of electronics in communication.
- Communication techniques based on Analog Modulation, Analog and digital Pulse Modulation including PAM, PWM, PPM, ASK, PSK, FSK are described in detail.
- Communication and Navigation systems such as GPS and mobile telephony system are introduced.

Course Learning Outcomes

At the end of this course, students will be able to develop following learning outcomes:

- the concepts of electronics in communication, introduction to the principle, performance and applications of communication systems.
- various means and modes of communication, electromagnetic communication spectrum with an idea of frequency allocation for radio communication system in India.
- an insight on the use of different modulation and demodulation techniques used in analog communication.
- analyze different parameters of analog communication techniques.
- learn the generation and detection of a signal through pulse and digital modulation techniques and multiplexing.
- In-depth understanding of different concepts used in a satellite communication system, Mobile radio propagation, cellular system design and understand mobile technologies like GSM and CDMA, mobile communication generations 2G, 3G, and 4G with their characteristics and limitations.

Unit 1

Electronic communication: Introduction to communication – means and modes. Power measurements (units of power). Need for modulation. Block diagram of an electronic communication system. Brief idea of frequency allocation for radio communication system in India (TRAI). Electromagnetic communication spectrum, band designations and usage. Channels and base-band signals.

(4 Lectures)

Analog Modulation: Amplitude Modulation, modulation index and frequency spectrum. Generation of AM (Emitter Modulation), Amplitude Demodulation (diode detector), Single Sideband (SSB) systems, advantages of SSB transmission, Concept of Single side band generation and detection. Frequency Modulation (FM) and Phase Modulation (PM), modulation index and frequency spectrum, equivalence between FM and PM, Generation of FM using VCO, FM detector (slope detector), Qualitative idea of Super heterodyne receiver.

(12 Lectures)

Unit 2

Analog Pulse Modulation: Channel capacity, Sampling theorem, Basic Principles-PAM, PWM, PPM, modulation and detection technique for PAM only, Multiplexing (time division multiplexing and frequency division multiplexing).

(9 Lectures)

Unit 3

Digital Pulse Modulation: Need for digital transmission, Pulse Code Modulation, Digital Carrier Modulation Techniques, Sampling, Quantization and Encoding. Concept of Amplitude Shift Keying (ASK), Frequency Shift Keying (FSK), Phase Shift Keying (PSK), and Binary Phase Shift Keying (BPSK).

(10 Lectures)

Unit 4

Satellite Communication: Introduction, need, Geosynchronous satellite orbits, geostationary satellite advantages of geostationary satellites. Transponders (C - Band), Uplink and downlink, path loss, Satellite visibility, Ground and earth stations. Simplified block diagram of earth station.

(10 Lectures)

Unit 5

Mobile Telephony System: Basic concept of mobile communication, frequency bands used in mobile communication, concept of cell sectoring and cell splitting, SIM number, IMEI number, need for data encryption, architecture (block diagram) of mobile communication network, idea of GSM, CDMA, TDMA and FDMA technologies, simplified block diagram of mobile phone handset, 2G, 3G and 4G concepts (qualitative only), GPS navigation system (qualitative idea only.

(15 Lectures)

Practical (60 Hours)
ELECTRONICS LAB: CC-3B LAB: COMMUNICATION ELECTRONICS LAB

"Sessions on the construction and use of specific measurement instruments and experimental apparatuses used in the lab, including necessary precautions.

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. Application to the specific experiments done in the lab."

At least 05 experiments from the following:

1. To design an Amplitude Modulator using Transistor
2. To study envelope detector for demodulation of AM signal
3. To study FM - Generator and Detector circuit
4. To study AM Transmitter and Receiver
5. To study FM Transmitter and Receiver
6. To study Time Division Multiplexing (TDM)
7. To study Pulse Amplitude Modulation (PAM)
8. To study Pulse Width Modulation (PWM)
9. To study Pulse Position Modulation (PPM)
10. To study ASK, PSK and FSK modulators

References for Theory

Essential Readings

1. Electronic Communications, D. Roddy and J. Coolen, Pearson Education India.
2. Advanced Electronics Communication Systems- Tomasi, 6thEdn. Prentice Hall.
3. Modern Digital and Analog Communication Systems, B.P. Lathi, 4th Edition, 2011, Oxford University Press.
4. Electronic Communication systems, G. Kennedy, 3rd Edn., 1999, Tata McGraw Hill.
5. Principles of Electronic communication systems – Frenzel, 3rd edition, McGraw Hill

Additional Readings

1. Communication Systems, S. Haykin, 2006, Wiley India.
2. Wireless communications, Andrea Goldsmith, 2015, Cambridge University Press.

References for Laboratory

1. Electronic Communication system, Blake, Cengage, 5th edition.
2. Introduction to Communication systems, U. Madhow, 1st Edition, 2018, Cambridge University Press.

CC-4B: Microprocessor and Microcontroller (42514413)
Credit: 06 (Theory-04, Practical-02)
Theory: 60 Hours
Practical: 60 Hours

Course Objective

- This paper introduces students with the architecture of microprocessor 8085 and microcontroller 8051.
- Here, students will learn about the 8085 programming, subroutines, Timing and control circuitry.
- Also, students will gain an exposure of 8051 I/O port programming and their addressing modes.
- By the end of syllabus, students will have an introductory knowledge of embedded systems.

Course Learning Outcomes

After having this course one is expected to have understanding of :

- designing and developing embedded systems.
- major components that constitute an embedded system.
- the architecture of a 8085 Microprocessor.
- assembly language programming essentials
- a microcontroller, microcomputer embedded system.
- the architecture of a 8051 microcontroller and its concepts like I/O operations, interrupts, programming of timers and counters.
- Interfacing of 8051 microcontroller with peripherals
- Implementing small programs to solve well-defined problems on an embedded platform.

Unit 1

Microcomputer Organization: Input/Output Devices. Data storage (idea of RAM and ROM). Computer memory. Memory organization & addressing. Memory Interfacing. Memory Map.

(5 Lectures)

8085 Microprocessor Architecture: Main features of 8085. Block diagram. Pin-out diagram of 8085. Data and address buses. Registers. ALU. Stack memory. Program counter.

(8 Lectures)

Unit 2

8085 Programming: Instruction classification, Instructions set (Data transfer including stacks. Arithmetic, logical, branch, and control instructions). Subroutines, delay loops. Timing & Control circuitry. Timing states. Instruction cycle, Timing diagram of MOV and MVI. Hardware and software interrupts.

(10 Lectures)

Unit 3

8051 Microcontroller: Introduction and block diagram of 8051 microcontroller, architecture of 8051, overview of 8051 family, 8051 assembly language programming, Program Counter and ROM memory map, Data types and directives, Flag bits and Program Status Word (PSW) register, Jump, loop and call instructions.

(12 Lectures)

8051 I/O port programming: Introduction of I/O port programming, pin out diagram of 8051 microcontroller, I/O port pins description & their functions, I/O port programming in 8051 (using assembly language), I/O programming: Bit manipulation.

(5 Lectures)

Unit 4

8051 Programming: 8051 addressing modes and accessing memory locations using various addressing modes, assembly language instructions using each addressing mode, arithmetic and logic instructions, 8051 programming in C: for time delay and I/O operations and manipulation, for arithmetic and logic operations, for ASCII and BCD conversions.

(15 Lectures)

Unit 5

Introduction to embedded system: Embedded systems and general purpose computer systems. Architecture of embedded system. Classifications, applications and purpose of embedded systems.

(5 Lectures)

PRACTICAL (60 Hours)
ELECTRONICS LAB: CC-4B LAB: MICROPROCESSOR AND MICROCONTROLLER LAB

"Sessions on the construction and use of specific measurement instruments and experimental apparatuses used in the lab, including necessary precautions.

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. Application to the specific experiments done in the lab."

At least 06 experiments each from Section-A and Section-B

Section-A: Programs using 8085 Microprocessor

1. Addition and subtraction of numbers using direct addressing mode
2. Addition and subtraction of numbers using indirect addressing mode
3. Multiplication by repeated addition.
4. Division by repeated subtraction.
5. Handling of 16-bit Numbers.
6. Use of CALL and RETURN Instruction.
7. Block data handling.
8. Other programs (e.g. Parity Check, using interrupts, etc.).

Section-B: Experiments using 8051 Microcontroller

1. To find that the given numbers is prime or not.
2. To find the factorial of a number.
3. Write a program to make the two numbers equal by increasing the smallest number and decreasing the largest number.
4. Use one of the four ports of 8051 for O/P interfaced to eight LED's. Simulate binary counter (8 bit) on LED's .
5. Program to glow the first four LEDs then next four using TIMER application.
6. Program to rotate the contents of the accumulator first right and then left.
7. Program to run a countdown from 9-0 in the seven segment LED display.
8. To interface seven segment LED display with 8051 microcontroller and display 'HELP' in the seven segment LED display.
9. To toggle '1234' as '1324' in the seven segment LED display.
10. Interface stepper motor with 8051 and write a program to move the motor through a given angle in clock wise or counter clockwise direction.
11. Application of embedded systems: Temperature measurement & display on LCD.

References for Theory

Essential Readings

1. Microprocessor Architecture Programming & applications with 8085, 2002, R.S. Goankar, Prentice Hall.
2. Embedded Systems:Architecture, Programming & Design, Raj Kamal, 2008, Tata McGraw Hill
3. The 8051 Microcontroller and Embedded Systems Using Assembly and C, M.A. Mazidi, J.G. Mazidi, and R.D. McKinlay, 2nd Ed., 2007, Pearson Education India.
4. Introduction to embedded system, K.V. Shibu, 1st edition, 2009, McGraw Hill
5. Microprocessors and Microcontrollers, Krishna Kant, 2nd Edition, 2016, PHI learning Pvt. Ltd.

Additional Readings

1. Microprocessor and Microcontrollers, N. Senthil Kumar, 2010, Oxford University Press
2. Embedded Systems: Design & applications, S.F. Barrett, 2008, Pearson Education India

References for Laboratory

1. 8051 microcontrollers, Satish Shah, 2010, Oxford University Press.
2. Embedded Microcomputer systems: Real time interfacing, J.W.Valvano 2011, Cengage Learning

9.2 DISCIPLINE SPECIFIC (PHYSICS ELECTIVE) SELECT TWO PAPERS

DSE-1B: Semiconductor Devices Fabrication (42517511)
Credit: 06 (Theory-04, Practical-02)
Theory: 60 Hours
Practical: 60 Hours

Course Objective

- This course provides a review of basics of semiconductors such as energy bands, doping, defects etc. and introduces students to various semiconductor and memory devices.
- Thin film growth techniques and processes including various vacuum pumps, sputtering, evaporation, oxidation and VLSI processing are described in detail.
- By the end of the syllabus, students will have an understanding of MEMS based transducers.

Course Learning Outcomes

At the end of this course, students will be able to achieve the following learning outcomes:

- Learn to distinguish between single crystal, polycrystalline and amorphous materials based on their structural morphology and learn about the growth of single crystals of silicon, using Czocharalski technique, on which a present day electronics and IT revolution is based.
- Students will understand about the various techniques of thin film growth and processes.
- Gain knowledge about characteristics of semiconductor devices (p-n junction diode, MOS, MOSFET, TUNNEL diode)
- Understanding of characteristics of Volatile and Non Volatile memory element and their classifications.
- Appreciate the various VLSI fabrication technologies and learn to design the basic fabrication process of R, C, P- N Junction diode, BJT, JFET, MESFET, MOS, NMOS, PMOS and CMOS technology.
- Gain basic knowledge on overview of MEMS (MicroElectro-Mechanical System) and MEMS based transducers.

Unit 1

Introduction: Review of energy bands in materials. Metal, Semiconductor and Insulator. Doping in Semiconductors, Defects: Point, Line, Schottky and Frenkel. Single Crystal, Polycrystalline and Amorphous Materials. Czochralski technique for Silicon Single Crystal Growth. Silicon Wafer Slicing and Polishing.

(5 Lectures)

Vacuum Pumps: Primary Pump (Mechanical) and Secondary Pumps (Diffusion, Turbo-molecular, Cryopump, Sputter - Ion)– basic working principle, Throughput and Characteristics in reference to Pump Selection. Vacuum Gauges (Pirani and Penning).

(6 Lectures)

Unit 2

Thin Film Growth Techniques and Processes: Sputtering, Evaporation (Thermal, electron-Beam, Pulse Laser Deposition (PLD), Chemical Vapor Deposition (CVD). Epitaxial Growth, Deposition by Molecular Beam Epitaxy (MBE).

(9 Lectures)

Thermal Oxidation Process (Dry and Wet) Passivation. Metallization. Diffusion of Dopants. Diffusion Profiles. Ion implantation.

(5 Lectures)

Unit 3

Semiconductor Devices: Review of p-n Junction diode, Metal-Semiconductor junction, Metal-Oxide-Semiconductor (MOS) capacitor and its C-V characteristics, MOSFET (enhancement and depletion mode) and its high Frequency limit. Microwave Devices: Tunnel diode.

(6 Lectures)

Unit 4

Memory Devices: Volatile Memory: Static and Dynamic Random Access Memory (RAM), Complementary Metal Oxide Semiconductor (CMOS) and NMOS, Non-Volatile - NMOS (MOST, FAMOS), Ferroelectric Memories, Optical Memories, Magnetic Memories, Charge Coupled Devices (CCD).

(10 Lectures)

Unit 5

VLSI Processing: Introduction of Semiconductor Process Technology, Clean Room Classification, Line width, Photolithography: Resolution and Process, Positive and Negative Shadow Masks, Photoresist, Step Coverage, Developer. Electron Beam Lithography. Idea of Nano-Imprint Lithography. Etching: Wet Etching. Dry etching (RIE and DRIE). Basic Fabrication Process of R, C, P-N Junction diode, BJT, JFET, MESFET, MOS, NMOS, PMOS and CMOS technology. Wafer Bonding, Wafer Cutting, Wire bonding and Packaging issues (Qualitative idea).

(12 Lectures)

Unit 6

Micro Electro-Mechanical System (MEMS): Introduction to MEMS, Materials selection for MEMS Devices, Selection of Etchants, Surface and Bulk Micromachining, Sacrificial Subtractive Processes, Additive Processes, Cantilever, Membranes. General Idea MEMS based Pressure, Force, and Capacitance Transducers.

(7 Lectures)

PRACTICAL (60 Hours)
PRACTICALS-DSE-1B LAB: SEMICONDUCTOR DEVICES FABRICATION LAB

"Sessions on the construction and use of specific measurement instruments and experimental apparatuses used in the lab, including necessary precautions.

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. Application to the specific experiments done in the lab.”

At least 05 experiments from the following:

1. Fabrication of alloy p-n Junction diode and study its I-V Characteristics.
2. Study the output and transfer characteristics of MOSFET.
3. To design and plot the static & dynamic characteristics of digital CMOS inverter.
4. Create vacuum in a small tube (preferably of different volumes) using a Mechanical rotary pump and measure pressure using vacuum gauges.
5. Deposition of Metal thin films/contacts on ceramic/thin using Thermal Evaporation and study IV characteristics.
6. Selective etching of Different Metallic thin films using suitable etchants of different concentrations.
7. Wet chemical etching of Si for MEMS applications using different concentration of etchant.
8. Calibrate semiconductor type temperature sensor (AD590, LM 35, LM 75).
9. Quantum efficiency of CCDs.
10. To measure the resistivity of a semiconductor (Ge) crystal with temperature (up to 150C) by four-probe method.
11. To fabricate a ceramic and study its capacitance using LCR meter.
12. To fabricate a thin film capacitor using dielectric thin films and metal contacts and study its capacitance using LCR meter.
13. Study the linearity characteristics of (a) Pressure using capacitive transducer (b) Distance using ultrasonic transducer

References for Theory

Essential Readings

1. Physics of Semiconductor Devices, S. M. Sze. Wiley-Interscience.
2. Handbook of Thin Film Technology, Leon I. Maissel and Reinhard Glang.
3. Fundamentals of Semiconductor Fabrication, S.M. Sze and G. S. May, John-Wiley and Sons, Inc.
4. Introduction to Semiconductor materials and Devices, M. S. Tyagi, John Wiley & Sons VLSI Fabrication Principles (Si and GaAs), S.K. Gandhi, John Wiley & Sons, Inc.

References for Laboratory

1. The science and Engineering of Microelectronics Fabrication, Stephen A. Champbell, 2010, Oxford University Press.
2. Introduction to Semiconductor Devices, Kelvin F. Brennan, 2010, Cambridge University Press.

DSE-1B : Electronic Instrumentation (42517512)
Credit: 06 (Theory-04, Practical-02)
Theory: 60 Hours
Practical: 60 Hours

Course Objective

- This course aims to provide an exposure on basics of measurement and instrumentation and its various aspects and their usage through hands-on mode.
- It also aims to provide exposure of various measurement instruments such as power supply, oscilloscope, multivibrators, signal generators are discussed in detail.
- It also aims to develop an understanding of virtual instrumentation and transducers.

Course Learning Outcomes

At the end of this course, students will have understanding of:

- basic principles of the measurement and errors in measurement, specifications of basic Measurement instruments and their significance with hands on mode.
- principles of voltage measurement, advantages of electronic voltmeter over conventional multimeter in terms of sensitivity etc.
- measurement of impedance using bridges, Power supply, Filters, IC regulators and Load and line regulation.
- Specifications of CRO and their significance, the use of CRO and DSO for the measurement of voltage (dc and ac), frequency and time period.
- Multivibrators, working circuits of Astable and monostable multivibrators.
- Phase Locked Loop (PLL), Voltage controlled oscillators and lock-In amplifier.
- explanation and specifications of Signal and pulse Generators
- the Interfacing techniques, Audrino microcontroller & interfacing software, Understanding and usage of Transducers.

Unit 1

Measurements: Accuracy and precision. Significant figures. Error and uncertainty analysis. Shielding and grounding. Electromagnetic Interference.

(3 Lectures)

Basic Measurement Instruments: DC measurement-ammeter, voltmeter, ohm meter, AC measurement, Digital voltmeter systems (integrating and non-integrating). Digital Multimeter; Block diagram principle of measurement of I, V, C. Accuracy and resolution of measurement. Measurement of Impedance- A.C. bridges, Measurement of Self Inductance (Anderson's bridge), Measurement of Capacitance (De-Sauty’s bridge), Measurement of frequency (Wien's bridge).

(12 Lectures)

Unit 2

Power supply: Block Diagram of a Power Supply, Qualitative idea of C and L Filters. IC Regulators (78XX and 79XX), Line and load regulation, Short circuit protection. Idea of switched mode power supply (SMPS) & uninterrupted power supply (UPS).

(4 Lectures)

Oscilloscope: Block Diagram, CRT, Vertical Deflection, Horizontal Deflection. Screens for CRT, Oscilloscope probes, measurement of voltage, frequency and phase by Oscilloscope. Digital Storage Oscilloscope. LCD display for instruments.

(10 Lectures)

Unit 3

Multivibrators (IC 555): Block diagram, Astable & Monostable multivibrator circuits. Phase Locked Loop (PLL): Basic Principles, Phase detector (XOR & edge triggered), Voltage Controlled Oscillator (Basics, varactor), lock and capture. Basic idea of PLL IC (565 or 4046). Lock-in-amplifier (qualitative only).

(11 Lectures)

Signal Generators: Function generator, Pulse Generator(qualitative only).

(3 Lectures)

Unit 4

Virtual Instrumentation: Introduction, Interfacing techniques (RS 232, GPIB, USB). Idea about Audrino microcontroller & interfacing software like lab View).

(5 Lectures)

Transducers: Classification of transducers, Basic requirement/characteristics of transducers, Active and Passive transducers, Resistive (Potentiometer- Theory, temperature compensation and applications), Capacitive (variable air gap type), Inductive (LVDT) and piezoelectric transducers. Measurement of temperature (RTD, semiconductor IC sensors), Light transducers (photo resistors & photovoltaic cells).

(12 Lectures)

PRACTICAL (60 Hours)
PRACTICALS-DSE-1B LAB: ELECTRONIC INSTRUMENTATION LAB

"Sessions on the construction and use of specific measurement instruments and experimental apparatuses used in the lab, including necessary precautions.

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. Application to the specific experiments done in the lab."

At least 06 experiments from the following

1. Measurement of resistance by Wheatstone bridge and measurement of bridge sensitivity.
2. Measurement of Capacitance by De Sauty's bridge.

3. To determine the Characteristics of resistance transducer - Strain Gauge (Measurement of Strain using half and full bridge).
4. To determine the Characteristics of LVDT.
5. To determine the Characteristics of Thermistors and RTD.
6. Measurement of temperature by Thermocouples.
7. Design a regulated power supply of given rating (5 V or 9V).
8. To design an Astable Multivibrator of given specification using IC 555 Timer.
9. To design a Monostable Multivibrator of given specification using IC 555 Timer.
10. To design and study the Sample and Hold Circuit.
11. To plot the frequency response of a microphone.
12. Glow an LED via USB port of PC.
13. Sense the input voltage at a pin of USB port and subsequently glow the LED connected with another pin of USB port.

References for Theory

Essential Readings

1. Electronic Instrumentation and Measurement Techniques, W.D. Cooper and A. D. Helfrick, Prentice Hall (2005).
2. Measurement Systems: Application and Design, E.O.Doebelin, McGraw Hill Book - fifth Edition (2003).
3. Electronic Devices and Circuits, David A. Bell, Oxford University Press (2015).
4. Instrumentation Devices and Systems, S. Rangan, G. R. Sarma and V. S. Mani, Tata McGraw Hill(1998).

References for Laboratory

1. “Measurement and Instrumentation Principles”, Alan S. Morris, Elsevier (Butterworth Heinmann-2008).
2. Basic Electronics: A text lab manual, P.B.Zbar, A.P.Malvino, M.A.Miller, 1990, Mc-Graw Hill.

DSE-1B: Digital Signal Processing (42517513)
Credit : 06 (Theory-04, Practical-02)
Theory : 60 Hours
Practical : 60 Hours

Course Objective

- This paper describes the discrete-time signals and systems, Fourier Transform Representation of Aperiodic Discrete-Time Signals.
- This paper also highlights the concept of filters and realization of Digital Filters.
- At the end of the syllabus, students will develop an understanding of Discrete and fast Fourier Transform.

Course Learning Outcomes

At the end of this course, students will be able to develop following learning outcomes:

- Students will learn basic discrete-time signal and system types, convolution sum, impulse and frequency response concepts for linear time-invariant (LTI) systems.
- The student will be in position to understand use of different transforms and analyze the discrete time signals and systems. They will learn to analyze a digital system using z-transforms and discrete time Fourier transforms, region of convergence concepts, their properties and perform simple transform calculations.
- The student will realize the use of LTI filters for filtering different real world signals. The concept of transfer Function and difference-Equation System will be introduced. Also, they will learn to solve Difference Equations.
- Students will develop an ability to analyze DSP systems like linear-phase, FIR, IIR, All-pass, averaging and notch Filter etc.
- Students will be able to understand the discrete Fourier transform (DFT) and realize its implementation using FFT techniques.
- Students will be able to learn the realization of digital filters, their structures, along with their advantages and disadvantages. They will be able to design and understand different types of digital filters such as finite & infinite impulse response filters for various applications.

Unit 1

Discrete-Time Signals and Systems: Classification of Signals, Transformations of the Independent Variable, Periodic and Aperiodic Signals, Energy and Power Signals, Even and Odd Signals, Discrete-Time Systems, System Properties. Impulse Response, Convolution Sum; Graphical Method; Analytical Method, Properties of Convolution; Commutative; Associative; Distributive; Shift; Sum Property System Response to Periodic Inputs, Relationship Between LTI System Properties and the Impulse Response; Causality; Stability; Invertibility, Unit Step Response.

(10 Lectures)

Unit 2

Discrete-Time Fourier Transform: Fourier Transform Representation of Aperiodic Discrete-Time Signals, Periodicity of DTFT, Properties; Linearity; Time Shifting; Frequency Shifting; Differencing in Time Domain; Differentiation in Frequency Domain; Convolution Property. The z-Transform: Bilateral (Two-Sided) z-Transform, Inverse z- Transform, Relationship Between z-Transform and Discrete-Time Fourier Transform, z-plane, Region-of- Convergence; Properties of ROC, Properties; Time Reversal; Differentiation in the z-Domain; Power Series Expansion Method (or Long Division Method); Analysis and Characterization of LTI Systems; Transfer Function and Difference-Equation System. Solving Difference Equations.

(15 Lectures)

Unit 3

Filter Concepts: Phase Delay and Group delay, Zero-Phase Filter, Linear-Phase Filter, Simple FIR Digital Filters, Simple IIR Digital Filters, All pass Filters, Averaging Filters, Notch Filters.

(5 Lectures)

Discrete Fourier Transform: Frequency Domain Sampling (Sampling of DTFT), The Discrete Fourier Transform (DFT) and its Inverse, DFT as a Linear transformation, Properties; Periodicity; Linearity; Circular Time Shifting; Circular Frequency Shifting; Circular Time Reversal; Multiplication Property; Parseval’s Relation, Linear Convolution Using the DFT (Linear Convolution Using Circular Convolution), Circular Convolution as Linear Convolution with aliasing.

(10 Lectures)

Unit 4

Fast Fourier Transform: Direct Computation of the DFT, Symmetry and Periodicity Properties of the Twiddle factor (WN), Radix-2 FFT Algorithms; Decimation-In-Time (DIT) FFT Algorithm; Decimation-In-Frequency (DIF) FFT Algorithm, Inverse DFT Using FFT Algorithms.

(5 Lectures)

Unit 5

Realization of Digital Filters: Non Recursive and Recursive Structures, Canonic and Non Canonic Structures, Equivalent Structures (Transposed Structure), FIR Filter structures; Direct-Form; Cascade-Form; Basic structures for IIR systems; Direct-Form I.
Finite Impulse Response Digital Filter: Advantages and Disadvantages of Digital Filters, Types of Digital Filters: FIR and IIR Filters; Difference Between FIR and IIR Filters, Desirability of Linear-Phase Filters, Frequency Response of Linear-Phase FIR Filters, Impulse Responses of Ideal Filters, Windowing Method; Rectangular; Triangular; Kaiser Window, FIR Digital Differentiators.
Infinite Impulse Response Digital Filter: Design of IIR Filters from Analog Filters, IIR Filter Design by Approximation of Derivatives, Backward Difference Algorithm, Impulse Invariance Method.

(15 Lectures)

PRACTICAL (60 Hours, 2 Credits)
PRACTICALS-DSE-1B LAB: DIGITAL SIGNAL PROCESSING LAB

"Introduction to Numerical computation software Scilab/Matlab be introduced in the lab.

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. Application to the specific experiments done in the lab"

At least 06 experiments from the following using Scilab/Matlab.

1. Write a program to generate and plot the following sequences: (a) Unit sample sequence $\delta(n)$, (b) unit step sequence $u(n)$, (c) ramp sequence $r(n)$, (d) real valued exponential sequence $x(n) = (0.8)^n u(n)$ for $0 \le n \le 50$.

2. Write a program to compute the convolution sum of a rectangle signal (or gate function) $x(n) = rect\left(\frac{n}{2N}\right) = \Pi\left(\frac{n}{2N}\right) = \begin{cases} 1 & -N \le n \le N \\ 0 & otherwise \end{cases}$ with itself for N = 5
3. An LTI system is specified by the difference equation $y(n) = 0.8y(n-1) + x(n)$
   (a) Determine $H(e^{jw})$

   (b) Calculate and plot the steady state response $y_{ss}(n)$ to

   $x(n) = \cos(0.5\pi n)u(n)$

4. Given a casual system $y(n) = 0.9y(n-1) + x(n)$
   (a) Find $H(z)$ and sketch its pole-zero plot

   (b) Plot the frequency response $\left|H(e^{jw})\right|$ and $\angle H(e^{jw})$

5. Design a digital filter to eliminate the lower frequency sinusoid of $x(t) = \sin 7t + \sin 200t$. The sampling frequency is $f_s = 500\ Hz$. Plot its pole zero diagram, magnitude response, input and output of the filter.
6. Let $x(n)$ be a 4-point sequence:

   $$x(n) = \underset{\uparrow}{\{1,1,1,1\}} = \begin{cases} 1 & 0 \le n \le 3 \\ 0 & otherwise \end{cases}$$

   Compute the DTFT $X(e^{jw})$ and plot its magnitude

   (a) Compute and plot the 4 point DFT of $x(n)$

   (b) Compute and plot the 8 point DFT of $x(n)$ (by appending 4 zeros)

   (c) Compute and plot the 16 point DFT of $x(n)$ (by appending 12 zeros

7. Let $x(n)$ and $h(n)$ be the two 4-point sequences, $x(n) = \underset{\uparrow}{\{1,2,2,1\}}$

   $$h(n) = \underset{\uparrow}{\{1,-1,-1,1\}}$$

   Write a program to compute their linear convolution using circular convolution.

8. Using a rectangular window, design a FIR low-pass filter with a pass-band gain of unity, cut off frequency of 1000 Hz and working at a sampling frequency of 5 KHz. Take the length of the impulse response as 17.
9. Design an FIR filter to meet the following specifications:
   Passband edge $F_p = 2\ KHz$
   Stopband edge $F_s = 5\ KHz$
   Passband attenuation $A_p = 2\ dB$

Stopband attenuation $A_s = 42\ dB$

Sampling frequency $F_s = 20\ KHz$

10. The frequency response of a linear phase digital differentiator is given by

$$H_d(e^{jw}) = jwe^{-j\tau w} |w| \leq \pi$$

Using a Hamming window of length M = 21, design a digital FIR differentiator. Plot the amplitude response.

References for Theory

Essential Readings

1. Digital Signal Processing, Tarun Kumar Rawat, 2015, Oxford University Press, India
2. Digital Signal Processing, S. K. Mitra, McGraw Hill, India.
3. Principles of Signal Processing and Linear Systems, B.P. Lathi, 2009, 1st Edn. Oxford University Press.
4. Fundamentals of signals and systems, P.D. Cha and J.I. Molinder, 2007, Cambridge University Press.
5. Digital Signal Processing Principles Algorithm & Applications, J.G. Proakis and D.G. Manolakis, 2007, 4th Edn., Prentice Hall.

Additional Readings

1. Digital Signal Processing, A. Anand Kumar, 2nd Edition, 2016, PHI learning Private Limited.
2. Digital Signal Processing, Paulo S.R. Diniz, Eduardo A.B. da Silva, Sergio L .Netto, 2nd Edition, 2017, Cambridge University Press.

References for Laboratory

1. A Guide to MATLAB, B.R. Hunt, R.L. Lipsman, J.M. Rosenberg, 2014, 3rd Edn., Cambridge University Press.
2. Fundamentals of Digital Signal processing using MATLAB, R.J. Schilling and S.L. Harris, 2005, Cengage Learning.
3. Getting started with MATLAB, Rudra Pratap, 2010, Oxford University Press.

DSE-2B: Verilog and FPGA based system Design (42517614)
Credit : 06 (Theory-04, Practical-02)
Theory : 60 Hours
Practical : 60 Hours

Course Objective

- This paper provides a review of combinational and sequential circuits such as multiplexers, demultiplexers, decoders, encoders and adder circuits.
- Evolution of Programmable logic devices such as PAL, PLA and GAL is explained.
- At the end of the syllabus, students will be able to understand the modeling of combinational and sequential circuits (including FSM and FSMD) with Verilog Design.

Course Learning Outcomes

This paper discusses the fundamental Verilog concepts in-lieu of today's most advanced digital design techniques. At the end of this course, students will be able to develop following learning outcomes:

- Understand the steps and processes for design of logic circuits and systems.
- Be able to differentiate between combinational and sequential circuits.
- Be able to design various types of state machines.
- Be able to partition a complex logic system into elements of data-path and control path.
- Understand various types of programmable logic building blocks such as CPLDs and FPGAs and their tradeoffs.
- Be able to write synthesizable Verilog code.
- Be able to write a Verilog test bench to test various Verilog code modules.
- Be able to design, program and test logic systems on a programmable logic device (CPLD or FPGA) using Verilog.

Unit 1

Digital logic design flow. Review of combinational circuits. Combinational building blocks: multiplexors, demultiplexers, decoders, encoders and adder circuits. Review of sequential circuit elements: flip-flop, latch and register. Finite state machines: Mealy and Moore. Other sequential circuits: shift registers and counters. FSMD (Finite State Machine with Datapath): design and analysis. Microprogrammed control. Memory basics and timing. Programmable Logic devices.

(20 lectures)

Unit 2

Evolution of Programmable logic devices. PAL, PLA and GAL. CPLD and FPGA architectures. Placement and routing. Logic cell structure, Programmable interconnects, Logic blocks and I/O Ports. Clock distribution in FPGA. Timing issues in FPGA design. Boundary scan.

(20 lectures)

Unit 3

Verilog HDL: Introduction to HDL. Verilog primitive operators and structural Verilog Behavioral Verilog. Design verification. Modeling of combinational and sequential circuits (including FSM and FSMD) with Verilog Design examples in Verilog.

(20 lectures)

PRACTICAL (60 Hours)
PRACTICALS-DSE-2B LAB: VERILOG AND FPGA LAB

"Sessions on the construction and use of specific measurement instruments and experimental apparatuses used in the lab, including necessary precautions.

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. Application to the specific experiments done in the lab."

At least 08 experiments from the following:

1. Write code to realize basic and derived logic gates.
2. Half adder, Full Adder using basic and derived gates.
3. Half subtractor and Full Subtractor using basic and derived gates.
4. Design and simulation of a 4 bit Adder.
5. Multiplexer (4x1) and Demultiplexer using logic gates.
6. Decoder and Encoder using logic gates.
7. Clocked D, JK and T Flip flops (with Reset inputs).
8. 3-bit Ripple counter.
9. To design and study switching circuits (LED blink shift).
10. To design traffic light controller.
11. To interface a keyboard.
12. To interface a LCD using FPGA.
13. To interface multiplexed seven segment display.
14. To interface a stepper motor and DC motor.
15. To interface ADC 0804.

References for Theory

Essential Readings

1. Principles of Digital Systems Design and VHDL, Lizy Kurien and Charles Roth; Cengage Publishing. ISBN-13:978-8131505748.
2. Verilog HDL, Samir Palnitkar, Pearson Education; Second edition (2003).
3. FPGA Based System Design, Wayne Wolf; Pearson Education,
4. Digital Signal processing, S. K. Mitra; McGraw Hill, 1998
5. VLSI design, Debaprasad Das; Oxford University Press, 2nd Edition, 2015.

Additional Readings

1. Digital Signal Processing with FPGAs, U. Meyer Baese; Springer, 2004
2. Verilog HDL primer- J. Bhasker. BSP, 2003

References for Laboratory

1. Digital System Designs and Practices: Using Verilog HDL and FPGAs, Ming-Bo Lin; Wiley India Pvt Ltd. ISBN-13: 978-8126536948.
2. Verilog Digital System Design, Zainalabedin Navabi; TMH; 2nd edition. ISBN-13: 978-0070252219.
3. Designing Digital Computer Systems with Verilog, D.J. Laja and S. Sapatnekar; Cambridge University Press, 2015.

DSE-2B: Photonic devices and Power Electronics (42517615)
Credit: 06 (Theory-04, Practical-02)
Theory: 60 Hours
Practical: 60 Hours

Course Objective

- This paper provides an insight on photonic devices such as Light Emitting Diodes, Semiconductor Laser, Laser diode, Photodetectors, Solar cell etc.
- Also, students will learn about LCD displays, their advantages over LED displays, evolution, elements, modes and configurations of optical fiber system.
- Emphasis is being laid to introduce students to power electronics, its need and applications.

Course Learning Outcomes

At the end of this course, students will be able to achieve the following learning outcomes:

- Develop understanding of application of fundamental laws of physics in such optoelectronics areas as telecommunications and power electronics for automation in industries.
- Acquire essential laboratory skills in designing experiments, assembling standard optical tools for optical experimentation and power electronics and analyzing acquired data.
- Identify the critical areas in application levels and derive typical alternative solutions, select suitable power converters to control Electrical Motors and other industry grade apparatus.
- Develop understanding to compare performance and basic operation of various power semiconductor devices, passive components and various switching circuits.
- Develop understanding of Basic circuit of power rectifiers and inverters.

Unit 1

Classification of photonic devices : Interaction of radiation and matter, Radiative transition and optical absorption. Light Emitting Diodes- Construction, materials and operation.

Semiconductor Laser- Condition for amplification, laser cavity, hetero-structure and quantum well devices. Charge carrier and photon confinement, line shape function. Threshold current. Laser diode.

(12 Lectures)

Unit 2

Photodetectors: Photoconductor. Photodiodes (p-i-n, avalanche) and Photo transistors, quantum efficiency and responsivity. Photomultiplier tube.

(5 Lectures)

Solar Cell: Construction, working and characteristics.

(2 Lectures)

LCD Displays: Types of liquid crystals, Principle of Liquid Crystal Displays, applications, advantages over LED displays.

(4 Lectures)

Unit 3

Introduction to Fiber Optics: Evolution of fiber optic system- Element of an Optical Fiber Transmission link- Ray Optics-Optical Fiber Modes and Configurations-Mode theory of Circular Wave guides- Overview of Modes-Key Modal concepts- Linearly Polarized Modes - Single Mode Fibers-Graded Index fiber structure.

(13 Lectures)

Unit 4

Power Devices: Need for semiconductor power devices, Power MOSFET (Qualitative). Introduction to family of thyristors. Silicon Controlled Rectifier (SCR)- structure, I-V characteristics, Turn-On and Turn-Off characteristics, ratings, Gate-triggering circuits. Diac and Triac- Basic structure, working and V-I characteristics. Application of Diac as a triggering device for Triac.

(10 Lectures)

Insulated Gate Bipolar Transistors (IGBT): Basic structure, I-V Characteristics, switching characteristics, device limitations and safe operating area (SOA).

(2 Lectures)

Unit 5

Applications of SCR: Phase controlled rectification, AC voltage control using SCR and Triac as a switch. Power Invertors- Need for commutating circuits and their various types, dc link invertors, Parallel capacitor commutated invertors, Series Invertor, limitations and its improved versions, bridge invertors.

(12 Lectures)

PRACTICAL (60 Hours, 2 Credits)
PRACTICALS-DSE-2B LAB: PHOTONIC DEVICES AND POWER ELECTRONICS LAB

"Sessions on the construction and use of specific measurement instruments and experimental apparatuses used in the lab, including necessary precautions.

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. Application to the specific experiments done in the lab."

***At least 06 experiments from the following*:**

1. To determine wavelength of sodium light using Michelson's Interferometer.
2. Diffraction experiments using a laser.
3. Study of Electro-optic Effect.
4. To determine characteristics of (a) LEDs, (b) Photo voltaic cell and (c) Photo diode.
5. To study the Characteristics of LDR and Photodiode with (i) Variable Illumination intensity, and (ii) Linear Displacement of source.
6. To measure the numerical aperture of an optical fiber.
7. Output and transfer characteristics of a power MOSFET.
8. Study of I-V characteristics of SCR.
9. SCR as a half wave and full wave rectifiers with R and RL loads.
10. AC voltage controller using TRIAC with UJT triggering.
11. Study of I-V characteristics of DIAC.
12. Study of I-V characteristics of TRIAC

References for Theory

Essential Readings

1. Optoelectronics, J. Wilson and J.F.B. Hawkes, Prentice Hall India (1996).
2. Optoelectronics and Photonics, S.O. Kasap, Pearson Education (2009).
3. Electronic Devices and Circuits, David A. Bell, 2015, Oxford University Press.
4. Introduction to fiber optics, A.K. Ghatak & K. Thyagarajan,Cambridge University Press(1998).
5. Power Electronics, M.D. Singh & K.B. Khanchandani, Tata McGraw Hill.

References for Laboratory

1. Power Electronics, P.C. Sen, Tata McGraw Hill.
2. Power Electronics Circuits, Devices & Applications, 3rd Edn., M.H.Rashid, Pearson Education.
3. A Textbook of Electrical Technology,Vol-II, B.L.Thareja, A.K.Thareja, S.Chand.

DSE-2B: Antenna Theory and wireless Network (42517616)
Credit : 06 (Theory-05, Tutorial-01)
Theory : 75 Hours

Course Objective

- This course gives an overview of wireless communication elements and networks.
- Students will develop an understanding of basics of antenna, its various parameters, its usage as a transmitter and receiver.
- Cellular concept and system design fundamentals are described and the evolution of current wireless systems real world such as 2G, 3G, 4G and LTE networks is discussed.

Course Learning Outcomes

At the end of this course, students will be able to achieve the following learning outcomes:

- Identify basic antenna parameter (Radiating wire Structures).
- Determine directions of maximum signal radiations and the nulls in the radiation patterns.
- Design array antenna systems from specifications.
- Identify the characteristics of radio-wave propagation.
- Identify Wireless Networks 4G and LTE, and 5G.
- Design Cellular Systems

Unit 1

ANTENNA THEORY:
Introduction: Antenna as an element of wireless communication system, Antenna radiation mechanism, Types of Antennas, Fundamentals of EMFT: Maxwell's equations and their applications to antennas.

(7 Lectures)

Antenna Parameters: Antenna parameters: Radiation pattern (polarization patterns, Field and Phase patterns), Field regions around antenna, Radiation intensity, Beam width, Gain, Directivity, Polarization, Bandwidth, Efficiency and Antenna temperature.

(9 Lectures)

Unit 2

Antenna as a Transmitter/Receiver: Effective Height and Aperture, Power delivered to antenna, Input impedance. Radiation from an infinitesimal small current element, Radiation from an elementary dipole (Hertzian dipole), Reactive, Induction and Radiation fields, Power density and radiation resistance for small current element and half wave dipole antenna.

(12 Lectures)

Unit 3

Radiating wire Structures (Qualitative idea only): Monopole, Dipole, Folded dipole, Loop antenna and Biconical broadband Antenna. Basics of Patch Antenna and its design. Examples of Patch antenna like bowtie, sectoral, fractal, etc.

(6 Lectures)

Propagation of Radio Waves: Different modes of propagation: Ground waves, Space waves, Space Wave propagation over flat and curved earth, Optical and Radio Horizons, Surface Waves and Troposphere waves, Ionosphere, Wave propagation in the Ionosphere. Critical Frequency, Maximum usable frequency (MUF), Skips distance. Virtual height. Radio noise of terrestrial and extraterrestrial origin. Elementary idea of propagation of waves used in terrestrial mobile communications.

(9 Lectures)

Unit 4

WIRELESS NETWORKS:
Introduction: History of wireless communication, Wireless Generation and Standards, Cellular and Wireless Systems, Current Wireless Systems, Cellular Telephone Systems, Wide Area Wireless Data Services, Broadband Wireless Access, Satellite Networks, Examples of Wireless Communication Systems. Idea about Global Mobile communication system.

(10 Lectures)

Unit 5

Modern Wireless Communication Systems: Second Generation (2G) Cellular Networks, Third Generation (3G) Wireless Networks, Wireless Local Loop (WLL), Wireless Local Area Networks (WLANs), Bluetooth and Personal Area Networks (PANs). Idea about Wi-Fi, 4G and LTE, and 5G.

(10 Lectures)

Unit 6

Cellular Concept and System Design Fundamentals: Cellular Concept and Cellular System Fundamentals, Frequency Reuse, Channel Assignment Strategies, Handoff strategies, Interference and System Capacity, Trunking and Grade of Service. Improving Coverage & Capacity in Cellular Systems. Cell Splitting and Sectoring. Cellular Systems design Considerations (Qualitative idea only).

(12 Lectures)

References for Theory

Essential Readings

1. Antenna Theory, Ballanis; John Wiley & Sons, (2003) 2nd Ed.
2. Electro Magnetic Waves and Radiating Systems, Jordan and Balmain, E. C.; PHI, 1968 Reprint (2003) 3rd Ed.
3. Fundamentals of Wireless Communication, D. Tse and P. Viswanathan; (2014) Cambridge University Press.
4. Wireless communication and Networks, Upena Dalal, 2015, Oxford University Press.
5. Mobile Communication Design and Fundamentals, Lee, William C.Y.; (1999) 4th Ed.

Additional Readings

1. Wireless communications, Andrea Goldsmith; (2015) Cambridge University Press.
2. Modern Wireless Communication, Haykin S. & Moher M. Pearson, (2005) 3rd Ed.

DSE-2B: Dissertation (42517617)
Credit: 08

Course Objective

Dissertation involves project work with the intention of exposing the student to research /development. It involves open ended learning based on student ability and initiative, exposure to scientific writing and inculcation of ethical practices in research and communication.

Course Learning Outcomes

- exposure to research methodology
- picking up skills relevant to dissertation project, such as experimental skills in the subject, computational skills, etc.
- development of creative ability and intellectual initiative
- developing the ability for scientific writing
- becoming conversant with ethical practices in acknowledging other sources, avoiding plagiarism, etc.

Guidelines for dissertation:

1. The dissertation work should not be a routine experiment or project at the under graduate level. It should involve more than text book knowledge. Referring text books for preparation and understanding concepts is allowed; however one component of the dissertation must include study of research papers or equivalent research material and/or open ended project.
2. The total number of dissertations allowed should be limited to 5% of the total strength of the students in the programme. However, students having national scholarships like NTSE, KVPY, INSPIRE, etc. can be considered above this quota. The selection criterion is at the discretion of the college. The student should not have any academic backlog (Essential Repeat). The sole/single supervisor must have a Ph.D. degree. Not more than two candidates would be enrolled under same supervisor.
3. At the time of submission of teaching work-load of the teachers by the college to the Department (Department of Physics and Astrophysics, Delhi University), the supervisor shall submit the proposal (200-300 words; not more than one full A4 page) of the proposed dissertation. Along with that four names of the external examiners from any college of Delhi University (other than the own college of the supervisor) or any department of Delhi University can be suggested. The committee of courses of the department may appoint any one teacher as an external examiner from the proposed list of external examiners.
4. No topic would be repeated from the topics allotted by the supervisor in the previous years, so that the work or dissertation could be distinct every time. The ‘proposal’ should include the topic, plan of work, and clearly state the expected deliverables. The topic must be well defined. The abstract should clearly explain the significance of the suggested problem. It must emphasize the specific skills which the student shall be learning during the course of dissertation, for example, some computational skill or literature survey, etc. Both internal (supervisor) and external examiners will assess the student at the end of the semester and award marks jointly, according to the attached scheme.

5. Other than the time for pursuing dissertation work, there must be at least 2 hours of interaction per week, of the student with the supervisor. The student has to maintain a "Log Book" to summarize his/ her weekly progress which shall be duly signed by the supervisor. Experimental work should be carried out in the parent college or any other college or the Department in Delhi University with the consent of a faculty member there. Unsupervised work carried out at research institutions / laboratories is to be discouraged.
6. The dissertation report should be of around 30 pages. It must have minimum three chapters namely (1) Introduction, (2) the main work including derivations / experimentation and Results, and (3) Discussion and Conclusion. At the end, adequate references must be included. Plagiarism should be avoided by the student and this should be checked by the supervisor.
7. It is left to the discretion of the college if it can allow relaxation of two teaching periods (at the most two periods per week to the supervisor, irrespective of the number of students enrolled under him / her for dissertation). The evaluation/presentation of the dissertation must be done within two weeks after the exams are over. For the interest of the students it is advised that college may organize a workshop for creating awareness amongst students. Any teacher who is not Ph.D. holder can be Co-supervisor with the main supervisor.

Assessment of dissertation

MARKING SCHEME for Dissertation:

- **30 marks:** Internal assessment based on performance like sincerity, regularity, etc. Awarded by: Supervisor
- **40 marks:**Written Report (including content and quality of work done). Awarded by: Supervisor and External Examiner.
- **30 marks:** Presentation*. Awarded by: Supervisor and External Examiner.

*All Dissertation presentations should be open. Other students / faculty should be encouraged to attend.

9.3 SKILL- ENHANCEMENT COURSES - (SEC)

Students should not take the same SEC paper in different Semesters

SEC: Computational Physics Skills (32223902)
Credit: 04 (Theory-02, Practical-02)
Theory: 30 Hours
Practical: 60 Hours

Course Objective

- This course is intended to give an insight into computers and their scientific applications.
- To familiarize students with use of computer to solve physics problems.
- To teach a programming language namely FORTRAN and data visualization using Gnuplot. To teach them to prepare long formatted document using latex.

Course Learning Outcomes

Students will be able to

- Use computers for solving problems in Physics.
- Prepare algorithm and flowchart for solving a problem.
- Use Linux commands on terminal
- Use an unformatted editor to write sources codes.
- Learn "Scientific Word Processing", in particular, using LaTeX for preparing articles, papers etc. which include mathematical equations, picture and tables.
- Learn the basic commands of Gnuplot.

Unit 1

Introduction: Importance of computers in Physics, paradigm for solving physics problems. Usage of editor in Linux.

Algorithms and Flowcharts: Algorithm: Definition, properties and development. Flowchart: Concept of flowchart, symbols, guidelines, types. Examples: Cartesian to Spherical Polar Coordinates, Roots of Quadratic Equation, Sum of two matrices, Sum and Product of a finite series, calculation of sin(x) as a series, algorithm for plotting (1) Lissajous figures and (2) trajectory of a projectile thrown at an angle with the horizontal.

(4 Lectures)

Scientific Programming: Some fundamental Linux Commands (Internal and External commands). Development of FORTRAN, Basic elements of FORTRAN: Character Set, Constants and their types, Variables and their types, Keywords, Variable Declaration and concept of instruction and program. Operators: Arithmetic, Relational, Logical and Assignment Operators. Expressions: Arithmetic, Relational, Logical, Character and Assignment Expressions. Fortran Statements: I/O Statements (unformatted/formatted), Executable and Non-Executable Statements, Layout of Fortran Program, Format of writing Program and concept of coding, Initialization and Replacement Logic. Examples from physics problems.

(5 Lectures)

Unit 2

Control Statements: Types of Logic(Sequential, Selection, Repetition), Branching Statements (Logical IF, Arithmetic IF, Block IF, Nested Block IF, SELECT CASE and ELSE IF Ladder statements), Looping Statements (DO- CONTINUE, DO-ENDDO, DO-WHILE, Implied and Nested DO Loops), Jumping Statements (Unconditional GOTO, Computed GOTO, Assigned GOTO) Subscripted Variables (Arrays: Types of Arrays, DIMENSION Statement, Reading and Writing Arrays), Functions and Subroutines (Arithmetic Statement Function, Function Subprogram and Subroutine), RETURN, CALL, COMMON and EQUIVALENCE Statements), Structure, Disk I/O Statements, open a file, writing in a file, reading from a file. Examples from physics problems.

Programming:

1. Exercises on syntax on usage of FORTRAN
2. Usage of GUI Windows, Linux Commands, familiarity with DOS commands and working in an editor to write sources codes in FORTRAN.
3. To print out all natural even/ odd numbers between given limits.
4. To find maximum, minimum and range of a given set of numbers.
5. Calculating Euler number using exp(x) series evaluated at x=1

(6 Lectures)

Unit 3

Scientific word processing: Introduction to LaTeX: TeX/LaTeX word processor, preparing a basic LaTeX file, Document classes, Preparing an input file for LaTeX, Compiling LaTeX File, LaTeX tags for creating different environments, Defining LaTeX commands and environments, Changing the type style, Symbols from other languages. Equation representation: Formulae and equations, Figures and other floating bodies, Lining in columns- Tabbing and tabular environment, Generating table of contents, bibliography and citation, Making an index and glossary, List making environments, Fonts, Picture environment and colors, errors.

(6 Lectures)

Unit 4

Visualization: Introduction to graphical analysis and its limitations. Introduction to Gnuplot. importance of visualization of computational and computational data, basic Gnuplot commands: simple plots, plotting data from a file, saving and exporting, multiple data sets per file, physics with Gnuplot (equations, building functions, user defined variables and functions), Understanding data with Gnuplot.

(9 Lectures)

PRACTICAL (60 Hours)
PRACTICALS: SEC LAB : COMPUTATIONAL PHYSICS SKILLS LAB

"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. Application to the specific experiments done in the lab."

Teacher may give a long duration project based on this paper.

Hands on exercises: (Use of latest FORTRAN compiler is advisable.)

1. To compile a frequency distribution and evaluate mean, standard deviation etc.
2. To evaluate sum of finite series and the area under a curve.
3. To find the product of two matrices
4. To find a set of prime numbers and Fibonacci series.
5. To write program to open a file and generate data for plotting using Gnuplot.
6. Plotting trajectory of a projectile projected horizontally.
7. Plotting trajectory of a projectile projected making an angle with the horizontally.
8. Creating an input Gnuplot file for plotting a data and saving the output for seeing on the screen. Saving it as an eps file and as a pdf file.
9. To find the roots of a quadratic equation.
10. Motion of a projectile using simulation and plot the output for visualization.
11. Numerical solution of equation of motion of simple harmonic oscillator and plot the outputs for visualization.
12. Motion of particle in a central force field and plot the output for visualization.

References

Essential Readings

1. Introduction to Numerical Analysis, S.S. Sastry, 5th Edn., 2012, PHI Learning Pvt. Ltd.
2. LaTeX–A Document Preparation System, Leslie Lamport (Second Edition, Addison-Wesley, 1994).
3. Gnuplot in action: understanding data with graphs, Philip K Janert, (Manning 2010)
4. Schaum's Outline of Theory and Problems of Programming with Fortran, S Lipsdutz and A Poe, 1986 Mc-Graw Hill Book Co.
5. Computational Physics: An Introduction, R. C. Verma, et al. New Age International Publishers, New Delhi(1999)
6. Elementary Numerical Analysis, K. E. Atkinson, 3rd Edn., 2007, Wiley India Edition.

Additional Readings

1. Computer Programming in Fortran 77. V. Rajaraman (Publisher:PHI).
2. Computational Physics - A practical Introduction to computational Physics and Scientific Computing; by Konstantinos N. Anagnostopoulos

SEC: Electrical Circuits and Network Skills (32223903)
Credit: 04 (Theory-02, Practical-02)
Theory: 30 Hours
Practical: 60 Hours

Course Objective

- To develop an understanding of basic principles of electricity and its household applications.
- To impart basic knowledge of solid state devices and its applications, understanding of electrical wiring and installation.

Course Learning Outcomes

At the end of this course, students will be able to

- Demonstrate good comprehension of basic principles of electricity including ideas about voltage, current and resistance.
- Develop the capacity to analyze and evaluate schematics of power efficient electrical circuits while demonstrating insight into tracking of interconnections within elements while identifying current flow and voltage drop.
- Gain knowledge about generators, transformers and electric motors. The knowledge would include to interfacing aspects and consumer defined control of speed and power.
- Acquire capacity to work theoretically and practically with solid-state devices.
- Delve into practical aspects related to electrical wiring like various types of conductors and cables, wiring-Star and delta connections, voltage drop and losses.
- Measure current, voltage, power in DC and AC circuits acquire proficiency in fabrication of regulated power supply.
- Develop capacity to identify and suggest types and sizes of solid and stranded cables, conduit lengths, cable trays, splices, crimps, terminal blocks and solder.

Unit 1

Basic Electricity Principles: Voltage, Current, Resistance, and Power. Ohm's law.Series, parallel, and series-parallel combinations. AC and DC Electricity. Familiarization with multimeter, voltmeter and ammeter.

(3 Lectures)

Electrical Circuits: Basic electric circuit elements and their combination. Rules to analyze DC sourced electrical circuits. Current and voltage drop across the DC circuit elements. Single-phase and three-phase alternating current sources. Rules to analyze AC sourced electrical circuits. Real, imaginary and complex power components of AC source. Power factor. Saving energy and money.

(4 Lectures)

Electrical Drawing and Symbols: Drawing symbols. Blueprints. Reading Schematics. Ladder diagrams. Electrical Schematics. Power circuits. Control circuits. Reading of circuit schematics. Tracking the connections of elements and identify current flow and voltage drop.

(4 Lectures)

Generators and Transformers: DC Power sources. AC/DC generators. Inductance, capacitance, and impedance. Operation of transformers.

(2 Lectures)

Electric Motors: Single-phase, three-phase & DC motors. Basic design. Interfacing DC or AC sources to control heaters and motors. Speed & power of ac motor.

(3 Lectures)

Unit 2

Solid-State Devices: Resistors, inductors and capacitors. Diode and rectifiers.Components in Series or in shunt. Response of inductors and capacitors with DC or AC sources.

(3 Lectures)

Electrical Protection: Relays. Fuses and disconnect switches. Circuit breakers. Overload devices. Ground-fault protection. Grounding and isolating. Phase reversal. Surge protection. Relay protection device.

(3 Lectures)

Electrical Wiring: Different types of conductors and cables. Basics of wiring-Star and delta connection. Voltage drop and losses across cables and conductors. Instruments to measure current, voltage, power in DC and AC circuits. Insulation. Solid and stranded cable. Conduit. Cable trays. Splices: wirenuts, crimps, terminal blocks, and solder. Preparation of extension board.

(5 Lectures)

Network Theorems: (1) Thevenin' theorem (2) Norton theorem (3) Superposition theorem (4) Maximum Power Transfer theorem.

(3 Lectures)

PRACTICAL (60 Hours)

"Sessions on the construction and use of specific measurement instruments and experimental apparatuses used in the lab, including necessary precautions.

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. Application to the specific experiments done in the lab."

Teacher may give a long duration project based on this paper.

At least 08 Experiments from the following:

1. Series and Parallel combinations: Verification of Kirchoff's law.
2. To verify network theorems: (I) Thevenin (II) Norton (III) Superposition theorem (IV) Maximum power transfer theorem
3. To study frequency response curve of a Series LCR circuit.
4. To verify: (1) Faraday's law and (2) Lenz's law.
5. Programming with Pspice/NG spice.

6. Demonstration of AC and DC generator.
7. Speed of motor
8. To study the characteristics of a diode.
9. To study rectifiers (I) Half wave (II) Full wave rectifier (III) Bridge rectifier
10. Power supply (I) C-filter, (II) π- filter
11. Transformer – Step up and Step down
12. Preparation of extension board with MCB/fuse, switch, socket-plug, Indicator.
13. Fabrication of Regulated power supply.

It is further suggested that students may be motivated to pursue semester long dissertation wherein he/she may do a hands-on extensive project based on the extension of the practicals enumerated above.

References for Theory

Essential Readings

1. Electrical Circuits, K.A. Smith and R.E. Alley, 2014, Cambridge University Press
2. Performance and design of AC machines - M G Say ELBS Edn.
3. Electronic Devices and Circuits, A Mothershead, 1998, PHI Learning Pvt. Ltd.
4. Network, Lines and Files, John D. Ryder, V Perarson 2nd Edn.,2015.

References for Laboratory

1. A text book in Electrical Technology - B L Theraja - S Chand & Co.

2. Electrical Circuit Analysis, K. Mahadevan and C. Chitran, 2nd Edition, 2018, PHI learning Pvt. Ltd.

SEC: Renewable Energy and Energy Harvesting (32223905)
Credit: 04 (Theory-02, Practical-02)
Theory: 30 Hours
Practical: 60 Hours

Course Objective

- To impart knowledge and hands on learning about various alternate energy sources.
- This paper describes the ways of harvesting energy using wind, solar, mechanical, ocean, geothermal energy and so on. To review the working of various energy harvesting systems which are installed worldwide.

Course Learning Outcomes

At the end of this course, students will be able to achieve the following learning outcomes:

- Knowledge of various sources of energy for harvesting
- Understand the need of energy conversion and the various methods of energy storage
- A good understanding of various renewable energy systems, and its components.
- Knowledge about renewable energy technologies, different storage technologies, distribution grid, smart grid including sensors, regulation and their control.
- Design the model for sending the wind energy or solar energy plant.
- The students will gain hand on experience of:
  (i) different kinds of alternative energy sources,
  (ii) conversion of vibration into voltage using piezoelectric materials,
  (iii) conversion of thermal energy into voltage using thermoelectric modules.

Unit 1

Fossil fuels and Alternate Sources of energy: Fossil fuels and nuclear energy, their limitation, need of renewable energy, non-conventional energy sources. An overview of developments in Offshore Wind Energy, Tidal Energy, Wave energy systems, Ocean Thermal Energy Conversion, solar energy, biomass, biochemical conversion, bio-gas generation, geothermal energy tidal energy, Hydroelectricity.

(3 Lectures)

Unit 2

Solar energy: Solar energy, its importance, storage of solar energy, solar pond, non-convective solar pond, applications of solar pond and solar energy, solar water heater, flat plate collector, solar distillation, solar cooker, solar green houses, solar cell, absorption air conditioning. Need and characteristics of photo-voltaic (PV) systems, PV models and equivalent circuits, and sun tracking systems.

(6 Lectures)

Unit 3

Wind Energy harvesting: Fundamentals of Wind energy, Wind Turbines and different electrical machines in wind turbines, Power electronic interfaces, and grid interconnection topologies.

(3 Lectures)

Unit 4

Ocean Energy: Ocean Energy Potential against Wind and Solar, Wave Characteristics and Statistics, Wave Energy Devices. Tide characteristics and Statistics, Tide Energy Technologies, Ocean Thermal Energy, Osmotic Power, Ocean Bio-mass.
Geothermal Energy: Geothermal Resources, Geothermal Technologies.
Hydro Energy: Hydropower resources, hydropower technologies, environmental impact of hydro power sources. Rain water harvesting.

(9 Lectures)

Unit 5

Piezoelectric Energy harvesting: Introduction, Physics and characteristics of piezoelectric effect, materials and mathematical description of piezo-electricity, Piezoelectric parameters and modeling piezoelectric generators, Piezoelectric energy harvesting applications, Human power.
Electromagnetic Energy Harvesting: Linear generators, physical/mathematical models, recent applications Carbon captured technologies, cell, batteries, power consumption

Environmental issues and Renewable sources of energy, sustainability. Merits of Rain Water harvesting .

(9 Lectures)

PRACTICAL (60 Hours)
PRACTICALS: SEC LAB: RENEWABLE ENERGY AND ENERGY HARVESTING SKILLS LAB

"Sessions on the construction and use of specific measurement instruments and experimental apparatuses used in the lab, including necessary precautions.

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. Application to the specific experiments done in the lab."

Teacher may give a long duration project based on this paper.

Demonstrations and Experiments:

1. Demonstration of Training modules on Solar energy, wind energy, etc.
2. Conversion of vibration to voltage using piezoelectric materials
3. Conversion of thermal energy into voltage-driven thermo-electric modules.

References for Theory

Essential Readings

1. Solar energy, Suhas P Sukhative, Tata McGraw - Hill Publishing Company Ltd.
2. Renewable Energy, Power for a sustainable future, Godfrey Boyle, 3rd Edn., 2012, Oxford University Press.

Additional Readings

1. Solar Energy: Resource Assessment Handbook, P Jayakumar, 2009
2. J.Balfour, M.Shaw and S. Jarosek, Photo-voltaics, Lawrence J Goodrich (USA).
3. http://en.wikipedia.org/wiki/Renewable_energy

References for Laboratory

1. Non-conventional energy sources, B.H. Khan, McGraw Hill 60

SEC: Engineering Design and Prototyping/Technical Drawing (32223906)
Credit: 04 (Theory-02, Practical-02)
Theory: 30 Hours
Practical: 60 Hours

Course Objective

- To introduce the students to modern visualization techniques and their applications in diverse areas including computer aided design.
- To offers hands-on experience of engineering drawing based on knowledge gained using computer aided designing software.

Course Learning Outcomes

This course will enable the student to be proficient in:

- Understanding the concept of a sectional view – visualizing a space after being cut by a plane. How The student will be able to draw and learn proper techniques for drawing an aligned sections.
- Understanding the use of spatial visualization by constructing an orthographic multi view drawing.
- Drawing simple curves like ellipse, cycloid and spiral, Orthographic projections of points, lines and of solids like cylinders, cones, prisms and pyramids etc.
- Using Computer Aided Design (CAD) software and AutoCAD techniques.

Unit 1

Introduction: Fundamentals of Engineering design, design process and sketching: Scales and dimensioning, Designing to Standards (ISO Norm Elements/ISI), Engineering Curves: Parabola, hyperbola, ellipse and spiral.

(4 Lectures)

Unit 2

Projections: Principles of projections, Orthographic projections: straight lines, planes and solids. Development of surfaces of right and oblique solids. Section of solids. Intersection and Interpenetration of solids. Isometric and Oblique parallel projections of solids.

(10 Lectures)

Unit 3

CAD Drawing: Introduction to CAD and Auto CAD, precision drawing and drawing aids, Geometric shapes, Demonstrating CAD specific skills (graphical user interface, create, retrieve, edit, and use symbol libraries). Use of Inquiry commands to extract drawing data. Control entity properties. Demonstrating basic skills to produce 2-D drawings. Annotating in Auto CAD with text and hatching, layers, templates and design centre, advanced plotting (layouts, viewports), office standards, dimensioning, internet and collaboration, Blocks, Drafting symbols, attributes, extracting data. Basic printing and editing tools, plot/print drawing to appropriate scale.

(10 Lectures)

Unit 4

Computer Aided Design and Prototyping: 3D modeling with AutoCAD (surfaces and solids), 3D modeling with Sketchup, 3D designs, Assembly: Model Editing; Lattice and surface optimization; 2D and 3D packing algorithms, Additive Manufacturing Ready Model Creation (3D printing), Technical drafting and Documentation.

(6 Lectures)

PRACTICAL (60 Hours)

PRACTICALS: SEC LAB : ENGINEERING DESIGN AND PROTOTYPING/ TECHNICAL DRAWING LAB

"Sessions on the construction and use of specific measurement instruments and experimental apparatuses used in the lab, including necessary precautions.

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. Application to the specific experiments done in the lab."

Teacher may give a long duration project based on this paper.

Five experiments based on the above theory.
Teacher may design at least five experiments based on the above syllabus.

References for Theory

Essential Readings

1. Engineering Graphic, K. Venugopal and V. Raja Prabhu, New Age International
2. Engineering Drawing, N.S. Parthasarathy and Vele Murali, Ist Edition, 2015, Oxford University Press
3. Don S. Lemons, Drawing Physics, MIT Press, M A Boston, 2018, ISBN:9780262535199
4. AutoCAD 2014 and AutoCAD 2014/Donnie Gladfelter/Sybex/ISBN:978-1-118-57510-9
5. Architectural Design with Sketchup/Alexander Schreyer/John Wiley & Sons/ISBN:978-1-118-12309-6.

Additional Readings

1. Engineering Drawing, Dhananjay A Jolhe, McGraw-Hill
2. James A. Leach, AutoCAD 2017 Instructor, SDC publication, Mission, KS 2016. ISBN: 978163057029.
3. Analysis of Mechanisms and Machines, M A Boston, McGraw-Hill, 2007.

SEC: Applied Optics (32223908)
Credit: 04 (Theory-02, Practical-02)
Theory: 30 Hours
Practical: 60 Hours

Course Objective

- This paper provides the conceptual understanding of various branches of modern optics to the students.
- This course introduces basic principles of LASER, Holography and signal transmission via optical fiber.

Course Learning Outcomes

Students will be able to:

- Understand basic lasing mechanism qualitatively, types of lasers, characteristics of laser light and its application in developing LED, Holography.
- Gain concepts of Fourier optics and Fourier transform spectroscopy.
- Understand basic principle and theory of Holography.
- Grasp the idea of total internal reflection and learn the characteristics of optical fibres.

Unit 1

Photo-sources and Detectors
Lasers: an introduction, Planck's radiation law (qualitative idea), Energy levels, Absorption process, Spontaneous and stimulated emission processes, Theory of laser action, Population of energy levels, Einstein's coefficients and optical amplification, properties of laser beam, Ruby laser, He-Ne laser, and semiconductor lasers; Light Emitting Diode (LED) and photo-detectors.

(9 lectures)

Unit 2

Fourier Optics and Fourier Transform Spectroscopy (Qualitative explanation) Concept of Spatial frequency filtering, Fourier transforming property of a thin lens, Fourier Transform Spectroscopy (FTS): measuring emission and absorption spectra, with wide application in atmospheric remote sensing, NMR spectrometry, and forensic science.

(6 lectures)

Unit 3

Holography
Introduction: Basic principle and theory: recording and reconstruction processes, Requirements of holography- coherence, etc. Types of holograms: The thick or volume hologram, Multiplex hologram, white light reflection hologram; application of holography in microscopy, interferometry, and character recognition.

(6 lectures)

Unit 4

Photonics: Fibre Optics

Optical fibres: Introduction and historical remarks, Total Internal Reflection, Basic characteristics of the optical fibre: Principle of light propagation through a fibre, the coherent bundle, The numerical aperture, Attenuation in optical fibre and attenuation limit; Single mode and multimode fibres, Fibre optic sensors: Fibre Bragg Grating.

(9 lectures)

PRACTICAL (60 Hours)
PRACTICALS: SEC LAB : APPLIED OPTICS LAB

"Sessions on the construction and use of specific measurement instruments and experimental apparatuses used in the lab, including necessary precautions.

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. Application to the specific experiments done in the lab."

Teacher may give a long duration project based on this paper.

Experiments on Lasers:

1. To determine the grating radial spacing of the Compact Disc (CD) by reflection using He-Ne or solid state laser.
2. To find the width of the wire or width of the slit using diffraction pattern obtained by a He-Ne or solid state laser.
3. To find the polarization angle of laser light using polarizer and analyzer d. Thermal expansion of quartz using laser.
4. To determine the wavelength and angular spread of laser light by using plane diffraction grating.

Experiments on Semiconductor Sources and Detectors:

5. V-I characteristics of LED.
6. Study the characteristics of solid state laser.
7. Study the characteristics of LDR.
8. Characteristics of Photovoltaic Cell/ Photodiode. e. Characteristics of IR sensor.

Experiments on Fourier Optics:

9. Optical image addition/subtraction.
10. Optical image differentiation.
11. Fourier optical filtering.
12. Construction of an optical 4f system

Experiments on Fourier Transform Spectroscopy:

To study the interference pattern from a Michelson interferometer as a function of mirror separation in the interferometer. The resulting interferogram is the Fourier transform of the power spectrum of the source. Analysis of experimental interferograms allows one to determine the transmission characteristics of several interference filters. Computer simulation can also be done.

Experiments on Holography and interferometry:

13. Recording and reconstruction of holograms (Computer simulation can also be done).
14. To construct a Michelson interferometer or a Fabry Perot interferometer.
15. To determine the wavelength of sodium light by using Michelson's interferometer.
16. To measure the refractive index of air.

Experiments on Fibre Optics:

17. To measure the numerical aperture of an optical fibre.
18. To measure the near field intensity profile of a fibre and study its refractive index profile.
19. To study the variation of the bending loss in a multimode fibre.
20. To determine the power loss at a splice between two multimode fibre.
21. To determine the mode field diameter (MFD) of fundamental mode in a single-mode fibre by measurements of its far field Gaussian pattern.

References

Essential Readings

1. LASERS: Fundamentals & applications, K. Thyagrajan & A. K. Ghatak, 2010, Tata McGraw Hill
2. Introduction to Fourier Optics, Joseph W. Goodman, The McGraw- Hill, 1996.
3. Introduction to Fiber Optics, A. Ghatak & K. Thyagarajan, Cambridge University Press.
4. Fibre optics through experiments, M.R.Shenoy, S.K.Khijwania, et.al. 2009, Viva Books
5. Optics, Karl Dieter Moller, Learning by computing with model examples, 2007, Springer.

Additional Readings

1. Optical Electronics, Ajoy Ghatak and K. Thyagarajan, 2011, Cambridge University Press
2. Optoelectronic Devices and Systems, S.C. Gupta, 2005, PHI Learning Pvt. Ltd.

SEC: Weather Forecasting (32223909)
Credit: 04 (Theory-02, Practical-02)
Theory: 30 Hours
Practical: 60 Hours

Course Objective

The aim of this course is to impart theoretical knowledge to the students and also to enable them to develop an awareness and understanding regarding the causes and effects of different weather phenomena and basic forecasting techniques.

Course Learning Outcomes

The student will gain the following:

- Acquire basic knowledge of the elements of the atmosphere, its composition at various heights, variation of pressure and temperature with height.
- To learn basic techniques to measure temperature and its relation with cyclones and anti-cyclones.
- Knowledge of simple techniques to measure wind speed and its directions, humidity and rainfall.
- Understanding of absorption, emission and scattering of radiations in atmosphere; Radiation laws.
- Knowledge of global wind systems, jet streams, local thunderstorms, tropical cyclones, tornadoes and hurricanes.
- Knowledge of climate and its classification. Understanding various causes of climate change like global warming, air pollution, aerosols, ozone depletion, acid rain.
- Develop skills needed for weather forecasting, mathematical simulations, weather forecasting methods, types of weather forecasting, role of satellite observations in weather forecasting, weather maps etc. Uncertainties in predicting weather based on statistical analysis.
- Develop ability to do weather forecasts using input data.
- In the laboratory course, students should be able to learn: Principle of the working of a weather Station, Study of Synoptic charts and weather reports, Processing and analysis of weather data, Reading of Pressure charts, Surface charts, Wind charts and their analysis.

Unit 1

Introduction to atmosphere: Elementary idea of atmosphere: physical structure and composition; compositional layering of the atmosphere; variation of pressure and temperature with height; air temperature; requirements to measure air temperature; temperature sensors: types; atmospheric pressure: its measurement.

(9 Lectures)

Unit 2

Measuring the weather: Wind; forces acting to produce wind; wind speed direction: units, its direction; measuring wind speed and direction; humidity, clouds and rainfall, radiation: absorption, emission and scattering in atmosphere; radiation laws.

(4 Lectures)

Unit 3

Weather systems: Global wind systems; air masses and fronts: classifications; jet streams; local thunderstorms; tropical cyclones: classification; tornadoes; hurricanes.

(3 Lectures)

Unit 4

Climate and Climate Change: Climate - Its classification; causes of climate change; global warming and its outcomes; air pollution and its measurement, particulate matters PM 2.5, PM 10. Health hazards due to high concentration of PM2.5; aerosols, ozone depletion.

(6 Lectures)

Unit 5

Basics of weather forecasting: Weather forecasting: analysis and its historical background; need of measuring weather; types of weather forecasting; weather forecasting methods; criteria of choosing weather station; basics of choosing site and exposure; satellites observations in weather forecasting; weather maps; uncertainty and predictability; probability forecasts.

(8 Periods)

PRACTICAL (60 Hours)
PRACTICALS: SEC LAB : WEATHER FORECASTING LAB

"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. Application to the specific experiments done in the lab."

Teacher may give a long duration project based on this paper.

Demonstrations and Experiments:

1. Study of synoptic charts & weather reports, working principle of weather station.
2. Processing and analysis of weather data:
   (a) To calculate the sunniest time of the year.
   (b) To study the variation of rainfall amount and intensity.
   (c) To observe the sunniest/driest day of the week.
   (d) To examine the maximum and minimum temperature throughout the year.
   (e) To evaluate the relative humidity of the day.
   (f) To examine the rainfall amount month wise.
3. Exercises in chart reading: Plotting of constant pressure charts, surfaces charts, upper wind charts and its analysis.
4. Formats and elements in different types of weather forecasts/ warning (both aviation and non-aviation).
5. Simulation of weather system
6. Field visits to India Meteorological department and National center for medium range weather forecasting

References

Essential Readings

1. Aviation Meteorology, I.C. Joshi, 3rd edition 2014, Himalayan Books

2. The weather Observers Hand book, Stephen Burt, 2012, Cambridge University Press.
3. Meteorology, S.R. Ghadekar, 2001, Agromet Publishers, Nagpur.
4. Text Book of Agrometeorology, S.R. Ghadekar, 2005, Agromet Publishers, Nagpur.
5. Atmosphere and Ocean, John G. Harvey, 1995, The Artemis Press.

SEC: Introduction to Physical Computing (xxx1)
Credit: 04 (Theory-02, Practical-02)
Theory: 30 Hours
Practical: 60 Hours

Course Objective

- Exposure to the elements of physical computing using embedded computers to enable the student to implement experimental setups in physics.
- To offer an opportunity to learn automation and to design an appropriate system for laboratory experiments using computer software in a project based learning environment.

Course Learning Outcomes

The students will be able to

- Understand the evolution of the CPU from microprocessor to microcontroller and embedded computers from a historical perspective.
- Operate basic electronic components and analog and digital electronics building blocks including power supply and batteries.
- Use basic laboratory equipment for measurement and instrumentation.
- Understand the Arduino ecosystem and to write simple Arduino programs (sketches)
- Understand sensor characteristics and how to select a suitable sensor for various applications.
- Read digital and analog data and produce digital and analog outputs from an embedded computer.
- Understand how to interface an embedded computer to the physical environment.
- Visualize the needs of a stand alone embedded computer and implement a simple system using Arduino.

Unit 1

Brief overview of a computer. Evolution from CPU to Microprocessor to microcontroller. Introduction to Arduino. Overview of basic electronic components (R, L, C, diode, BJT, MOSFET etc.) and circuits, 555 timer, logic gates, logic function ICs, power supply and batteries.

(4 Lectures)

Unit 2

Capturing schematic diagrams. Using free software such as Eagle CAD. Using basic lab instruments – DMM, oscilloscope, signal generator etc.

(6 Lectures)

Unit 3

Understanding Arduino programming. Downloading and installing Arduino IDE. Writing an Arduino sketch. Programming fundamentals: program initialization, conditional statements, loops, functions, global variables.

(5 Lectures)

Unit 4

Digital Input and Output. Measuring time and events. Pulse Width Modulation.

(6 Lectures)

Unit 5

Analog Input and Output. Physical Interface: sensors and actuators.

(6 Lectures)

Unit 6

Communication with the outside world. System Integration and debugging.

(**3 Lectures)**

PRACTICAL (60 Hours)
PRACTICALS: SEC LAB: INTRODUCTION TO PHYSICAL COMPUTING LAB

"Sessions on the construction and use of specific measurement instruments and experimental apparatuses used in the lab, including necessary precautions.

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. Application to the specific experiments done in the lab."

Teacher may give a long duration project based on this paper.

1. Hello LED: Connect a LED to a digital output pin and turn it on and off.
2. Hello Switch: Read a switch a toggle an LED when the switch is pressed and released.
3. Hello ADC: Connect a potentiometer to an ADC input and print the analog voltage on the serial monitor.

4. Hello Blink: Read a switch and changing the LED blink rate every time the switch is pressed and released.
5. Hello PWM: Write a Pulse Width Modulation code in software and vary the LED intensity.
6. Hello Random: Read a switch and every time the switch is pressed and released, generate and print a random number on the serial monitor.
7. Hello Random2: Connect a Seven Segment Display (SSD) and print the random number on this display each time a switch is pressed and released. Collect large data sample and plot relative frequency of occurrence of each 'random' number
8. Hello LCD: Connect a (16X2) LCD to an Arduino and print 'Hello World'.
9. Hello LCD2: Connect a temperature sensor to an ADC input and print the temperature on the LCD
10. Hello PWM2: Connect a RGB LED and 3 switches. Use hardware PWM feature of the Arduino and change the relative intensity of each of the LEDs of the RGB LED and generate large number of colors.

Mini Projects:

1. Connect 2 SSDs and every time a switch is pressed and released, print 2 random numbers on the two SSDs
2. Connect a switch and 4 RGB LEDs in a 'Y' configuration. Change the LED lighting patterns each time a switch is pressed and released (total 4095 patterns possible).
3. Arrange acrylic mirrors in a triangle and make a LED kaleidoscope using the RGB LEDs as the light source.
4. Connect a photo-gate mechanism to a bar pendulum. Verify that the period of oscillation is independent of the amplitude for small amplitudes. What happens when the amplitude is large?
5. Connect 8 switches and a small speaker and an audio amplifier and make a piano.
6. Connect 2 sets of 3 switches for two players. Connect LCD and implement a 'rock-paper-scissors' game.

References

Essential Readings

1. Learn Electronics with Arduino: An Illustrated Beginner's Guide to Physical Computing. Jody Culkin and Eric Hagan. Shroff Publishers. ISBN: 9789352136704.
2. Programming Arduino: Getting Started with Sketches, Second Edition. Simon Monk. McGraw-Hill Education. ISBN-10: 1259641635.
3. Physical Computing: Sensing and Controlling the Physical World with Computers, 1st Edition. Thomson. ISBN-10: 159200346X.
4. The Art of Electronics. Paul Horowitz and Winfield Hill. Cambridge University Press. 2^{nd} Edition. ISBN-13: 978-0521689175
5. Designing Embedded Hardware. John Catsoulis. Shroff Publishers. 2^{nd} Edition. ISBN: 9788184042597

SEC: Numerical Analysis (xxx2)
Credit: 04 (Theory-02, Practical-02)
Theory: 30 Hours
Practical: 60 Hours

Course Objective

- The emphasis of course is to equip students with the mathematical tools required in solving problem of interest to physicists.
- To expose students to fundamental computational physics skills and hence enable them to solve a wide range of physics problems.
- To help students develop critical skills and knowledge that will prepare them not only for doing fundamental and applied research but also prepare them for a wide variety of careers.

Course Learning Outcomes

Theory:

After completing this course, student will be able to

- approximate single and multi-variable function by Taylor's Theorem.
- Solve first order differential equations and apply it to physics problems.
- solve linear second order homogeneous and non-homogeneous differential equations with constant coefficients.
- Calculate partial derivatives of function of several variables
- Understand the concept of gradient of scalar field and divergence and curl of vector fields. perform line, surface and volume integration
- Use Green's, Stokes' and Gauss's Theorems to compute integrals

Practical:

After completing this course, student will be able to :

- design, code and test simple programs in C++ learn Monte Carlo techniques,

fit a given data to linear function using method of least squares find roots of a given non-linear function

- Use above computational techniques to solve physics problems

Unit 1

Errors and iterative Methods: Truncation and Round-off Errors. Floating Point Computation, Overflow and underflow. Single and Double Precision Arithmetic, Iterative Methods.

(2 Lectures)

Solutions of Algebraic and Transcendental Equations: (1) Fixed point iteration method, (2) Bisection method, (3) Secant Method, (4) Newton Raphson method, (5) Generalized Newton's method. Comparison and error estimation.

(6 Lectures)

Unit 2

Interpolation: Forward and Backward Differences. Symbolic Relation, Differences of a polynomial. Newton's Forward and Backward Interpolation Formulas.

(5 Lectures)

Unit 3

Least Square fitting: (1) Fitting a straight line. (2) Non-linear curve fitting: (a) Power function, (b) Polynomial of nth degree, and (c) Exponential Function. (3) Linear Weighed Least square Approximation.

(5 Lectures)

Unit 4

Numerical Differentiation: (1) Newton's interpolation Formulas & (2) Cubic Spline Method, Errors in Numeric Differentiation. Maximum and Minimum values of a Tabulated Function.

(4 Lectures)

Numerical Integration: Generalized Quadrature Formula. Trapezoidal Rule. Simpson's 1/3 and 3/8 Rules. Weddle's Rule, Gauss-Legendre Formula.

(4 Lectures)

Solution of Ordinary Differential Equations: First Order ODE's: solution of Initial Value problems: (1) Euler's Method, (2) Modified Euler's method.

(4 Lectures)

PRACTICAL (60 Hours)
PRACTICALS: SEC LAB : NUMERICAL ANALYSIS COMPUTING LAB

At least 08 Experiments from the following:

"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. Application to the specific experiments done in the lab."

Teacher may give a long duration project based on this paper.

Algebraic and transcendental equation:

1. To find the roots of an algebraic equation by Bisection method.
2. To find the roots of an algebraic equation by Secant method.
3. To find the roots of an algebraic equation by Newton-Raphson method.
4. To find the roots of a transcendental equation by Bisection method. Interpolation
5. To find the forward difference table from a given set of data values.
6. To find a backward difference table from a given set of data values. Curve fitting
7. To fit a straight line to a given set of data values.
8. To fit a polynomial to a given set of data values.
9. To fit an exponential function to a given set of data values.

Differentiation:

10. To find the first and second derivatives near the beginning of the table of values of (x,y).
11. To find the first and second derivatives near the end of the table of values of (x,y). Integration
12. To evaluate a definite integral by trapezoidal rule.
13. To evaluate a definite integral by Simpson 1/3 rule.
14. To evaluate a definite integral by Simpson 3/8 rule.
15. To evaluate a definite integral by Gauss Quadrature rule.

Differential Equations:

16. To solve differential equations by Euler's method.
17. To solve differential equations by modified Euler's method.

References

Essential Readings

1. Elementary Numerical Analysis, K.E.Atkinson, 3rd Edn., 2007 , Wiley India Edition.
2. Introduction to Numerical Analysis, S.S. Sastry, 5th Edn., 2012, PHI Learning Pvt. Ltd.
3. A first course in Numerical Methods, U.M. Ascher & C. Greif, 2012, PHI Learning.

References for Laboratory

1. Schaum's Outline of Programming with C++. J.Hubbard, 2000, McGraw Hill Pub.
2. Numerical Recipes in C++: The Art of Scientific Computing, W.H. Press et.al., 2nd Edn., 2013, Cambridge University Press.
3. An introduction to Numerical methods in C++, Brian H. Flowers, 2009, Oxford University Press.

ANNEXURE-1A

Steering Committee
LOCF (CBCS) Undergraduate Physics courses revision 2019
Department of Physics & Astrophysics, University of Delhi

1. Prof. Sanjay Jain – HoD (Chairman)
2. Prof. A. G. Vedeshwar – (Coordinator)
3. Prof. Vinay Gupta – (Convener)
4. Prof. Debajyoti Choudhury
5. Prof. P. Das Gupta
6. Prof. S. Annapoorni
7. Prof. H.P. Singh
8. Prof. T.R. Seshadri
9. Prof. Anjan Dutta
10. Prof. S.K. Mandal
11. Prof. Kirti Ranjan
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13. Dr. Mallika Verma (Department of Physics, Miranda House)
14. Dr. Anuradha Gupta (Department of Physics, SGTB Khalsha College)
15. Dr. Sangeeta D. Gadre (Department of Physics, Kirori Mal College)
16. Dr. Jacob Cherian (Department of Physics, St. Stephens' College)
17. Dr. Vandana Luthra (Department of Physics, Gargi College)
18. Dr. Mamta (Department of Physics, SGTB Khalsa College)
19. Dr. P.K. Jha (Department of Physics, Deen Dyal Upadhyaya College)
20. Dr. Sanjay Kumar (Department of Physics, St. Stephens' College)
21. Dr. Abhinav Gupta (Department of Physics, St. Stephen's College)
22. Dr. Monika Tomar (Department of Physics, Miranda House)
23. Dr. Roshan Kshetrimayum (Department of Physics, Kirori Mal College)
24. Mr. Ashish Tyagi (Department of Physics, Swami Shraddhanand College)
25. Dr. Shalini Lumb Talwar (Department of Physics, Maitreyi College)
26. Dr. Shiva Upadhyay (Department of Physics, Swami Shraddhanand College)
27. Dr. Divya Haridas (Department of Physics, Keshav Mahavidyalaya)
28. Dr. Chetana Jain (Department of Physics, Hansraj College)

ANNEXURE 1B

Subject working groups
LOCF (CBCS) Undergraduate Physics courses revision 2019
Department of Physics & Astrophysics, University of Delhi

Group	Papers	Name of faculty	Role	College
I	• Waves and Optics (Hons. core /GE) • Electricity and magnetism (Hons. core/GE) • Electromagnetic theory (Hons. core) • Electricity and magnetism (Prog. core) • Waves and Optics (Prog. core) • Electrical circuits and Networks (SEC) • Applied Optics (SEC) • Introduction to Physical Computing (SEC)	Prof. Kirti Ranjan	Coordinator	Department of Physics & Astrophysics
		Dr. Sangeeta D. Gadre	Convenor	Kirori Mal College
		Dr. Pragati Ishdhir	Member	Hindu College
		Dr. K.C. Singh		Sri Venkateswara College
		Dr. Pushpa Bindal		Kalindi College
		Dr. Geetanjali Sethi		St. Stephen's College
		Dr. Pradeep Kumar		Hansraj College
		Dr. N. Chandrlika		Gargi College
II	• Elements of Modern Physics (Hons. core/GE) • Quantum Mechanics and applications (Hons. Core) • Elements of Modern Physics (Prog. DSE) • Quantum Mechanics (Prog. DSE/GE) • Advanced Quantum Mechanics (Hons. DSE) • Renewable energy and Energy harvesting (SEC)	Prof. P. Das Gupta	Coordinator	Department of Physics & Astrophysics
		Dr. P.K. Jha	Convenor	Deen Dyal Upadhyaya college
		Dr. N. Santakrus Singh		Hindu College
		Dr. Punita Verma		Kalindi College
		Dr. Siddharth Lahon		Kirorimal College
		Dr. Onkar Mangla		Daulat Ram College
		Dr. Sandhya		Miranda House

		Dr. Ajay Kumar		Sri Aurobindo College
III	• Thermal Physics (Hons. Core) • Statistical Mechanics (Hons. Core) • Thermal Physics and Statistical Mechanics (Program core/GE)	Prof. S. Annapoorni	Coordinator	Department of Physics & Astrophysics
		Dr. Anuradha Gupta	Convenor	SGTB Khalsa College
		Dr. Deepak Jain	Member	Deen Dyal Upadhyaya college
		Dr. Nimmi Singh		SGTB Khalsa College
		Dr. Ashok Kumar		Ramjas College
		Dr. Aditya Saxena		Deshbandhu College
		Dr. Maya Verma		Hansraj College
IV	• Solid State Physics (Hons. Core) • Solid State Physics (Prog. DSE/GE) • Nanomaterials and Applications (DSE-Hons.+ Prog.)/GE	Prof. S. Annapoorni	Coordinator	Department of Physics & Astrophysics
		Dr. Divya Haridas	Convenor	Keshav Mahavidyalaya
		Dr. Mamta Bhatia	Member	AND College
		Dr. Rajveer Singh		ARSD College
		Dr. Shiva Upadhyaya		S.S.N. College
		Dr. Harish K. Yadav		St. Stephen's College
		Dr. Rashmi Menon		Kalindi College
		Dr. Yogesh Kumar		Deshbandhu College
V	• Mathematical Physics-I (Hons. Core) • Mathematical Physics-II (Hons. Core) • Mathematical Physics -III	Prof. T.R. Seshadri	Coordinator	Department of Physics & Astrophysics
		Dr. G.S. Chilana	Convenor	Ramjas College

	(Hons. Core) ● Advanced Mathematical Physics (Hons. DSE) ● Mathematical Physics (Program DSE/ Hons. GE) ● Advanced Mathematical Physics -II (Hons. DSE) ● Computational Physics Skills (SEC) ● Numerical Analysis (SEC) ● Linear Algebra & Tensor Analysis (DSE)	Dr. Abha Dev Habib	Member	Miranda House
		Dr. Agam Kumar Jha		Kirori Mal College
		Dr. Subhash Kumar		AND College
		Dr. Mamta		SGTB Khalsa College
		Dr. Neetu Aggarwal		Daulat Ram College
		Dr. Bhavna Vidhani		Hansraj College
		Dr. Ajay Mishra		Dyal Singh College
VI	● Mechanics (Hons. Core/GE) ● Mechanics (Prog. Core) ● Applied Dynamics (DSE/GE) ● Classical Dynamics (DSE) ● Physics Workshop Skills (SEC)	Prof. A. G. Vedeshwar	Coordinator	Department of Physics & Astrophysics
		Dr. Ashish Tyagi	Convenor	SSN College
		Dr. Shalini Lumb Talwar	Member	Maitreyi College
		Dr. Vandana Arora		Keshav Mahavidyalaya
		Dr. Arvind Kumar		Ramjas College
		Dr. Chitra Vaid		Bhagini Nivedita College
		Dr. Omwati Rana		Daulat Ram College
		Dr. Sunita Singh		Miranda House
		Dr. Pranav Kumar		Kirori Mal College
		Dr. Pooja Devi		Shyam lal College
VII	● Nuclear and particle Physics (Hons. DSE/GE) ● Nuclear and particle physics (Prog. DSE) ● Radiation Safety (SEC)	Prof. Samit Mandal	Coordinator	Department of Physics & Astrophysics
		Dr. Vandana Luthra	Convenor	Gargi College

		Dr. Namrata	Member	S.S.N. College
		Dr. Supriti Das		Gargi College
		Dr. Punit Tyagi		Ramjas College
VIII	• Astronomy and Astrophysics (DSE/GE) • Weather Forecasting (SEC) • Medical Physics (DSE/GE) • Atmospheric Physics (DSE/GE) • Biological Physics (DSE/GE) • Physics of Earth (DSE/GE) • Technical Drawing (SEC) • Dissertation	Prof. Anjan Datta	Coordinator	Department of Physics & Astrophysics
		Dr. Jacob Cherian	Convenor	St. Stephen's College
		Dr. S.K. Dhaka	Member	Rajdhani College
		Dr. Sanjay Kumar		St. Stephen's College
		Dr. Sushil Singh		SGTB Khalsa College
		Dr. Chetna Jain		Hansraj College
		Dr. Ayushi Paliwal		Deshbandhu College
		Dr. Rekha Gupta		St. Stephen's College
IX	• Digital Systems and Applications (Hons. Core) • Embedded Systems - Introduction to Microcontroller (DSE/GE) • Digital, Analog and Instrumentation (Prog. DSE/Hons. GE) • Verilog and FPA based System design (DSE/GE) • Digital Signal Processing (DSE/GE) • Linear and Digital Integrated Circuits –E • Microprocessors and Microcontrollers –E • Electronic Instrumentation - E(DSE) • Basic Instrumentation Skills (SEC)	Prof. Vinay Gupta	Coordinator	Department of Physics & Astrophysics
		Dr. Mallika Verma	Convenor	Miranda House
		Dr. Shashi Bala	Member	Ramjas College
		Dr. Arijit Chowdhuri		AND College
		Dr. Anjali Sharma		ARSD College
		Dr. Kajal Jindal		Kirori Mal College
		Dr. Poonam Jain		Sri Aurobindo College
		Dr. Savita Sharma		Kalindi College

	Dissertation-E	Dr. Alka Garg		Gargi College
X	• Analog systems and Applications (Hons. Core) • Experimental techniques (DSE) • Physics of Device and Communication (DSE) • Communication System (DSE/GE) • Network Analysis and Analog Electronics-E • Communication Electronics –E • Semiconductor Devices Fabrication - E(DSE) • Photonic Devices and Power Electronics -E (DSE) • Antenna theory and wireless network -E (DSE) • Electrical circuit network skills-Prog. SEC	Prof. Vinay Gupta	Coordinator	Department of Physics & Astrophysics
		Dr. Monika Tomar	Convenor	Miranda House
		Dr. Sanjay Tandon	Member	Deen Dyal Upadhyaya college
		Dr. Sangeeta Sachdeva		St. Stephen's College
		Dr. Roshan		Kirorimal College
		Dr. Kuldeep Kumar		SGTB Khalsa College
		Dr. Reema Gupta		Hindu College
XI	• Practicals of all Courses	Prof. Vinay Gupta	Coordinator	Department of Physics & Astrophysics
		Dr. Sanjay Kumar	Convenor	St. Stephen's College
		Prof. P. D. Gupta	Member	Department of Physics & Astrophysics
		Prof. A.G. Vedeshwar		Department of Physics & Astrophysics

		Prof. Samit Mandal		Department of Physics & Astrophysics
		Dr. G.S. Chilana		Ramjas College
		Dr. Mallika Verma		Miranda House
		Dr. Anuradha Gupta		SGTB Khalsa College
		Dr. Monika Tomar		Miranda House
		Dr. Sangeeta D. Gadre		Kirori Mal College
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ANNEXURE 1C

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LOCF (CBCS) Undergraduate Physics courses revision 2019
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दिल्ली विश्वविद्यालय
UNIVERSITY OF DELHI

Bachelor of Science in Physical Sciences
Discipline: Physics

(Effective from Academic Year 2019-20)

Revised Syllabus as approved by

Date:	**Academic Council**	No:
Date:	**Executive Council**	No:

Applicable for students enrolled with Regular Colleges.

List of Contents

Page No.

Preamble

Higher Education in India is in need of reform. On the one hand, while there is a need for increased access to higher education in the country, it is also necessary to improve the quality of higher education. New initiatives and sustained efforts are needed to develop and enhance the spirit of enquiry, analytical ability and comprehension skills of the young generation of students. An emerging knowledge based society requires that they are able to acquire and generate new knowledge and skills, and can creatively apply them to excel in their chosen vocations. Our higher education system needs to inculcate exemplary citizenship qualities and motivate students to contribute to the society at large. Such abilities and qualities of our youth will be crucial for the country to face the challenges of the future.

One of the reforms in undergraduate (UG) education, initiated by the University Grants Commission (UGC) at the national level in 2018, is to introduce the Learning Outcomes-based Curriculum Framework (LOCF) which makes it student-centric, interactive and outcome-oriented with well- defined aims and objectives.

The Department of Physics and Astrophysics, University of Delhi took up the task of drafting the LOCF for UG Physics courses according to guidelines sent in March 2019 by the Undergraduate Curriculum Review Committee (UGCRC)-2019 of the University of Delhi. The Committee of Courses of the Department constituted a Steering Committee, whose composition is given in Annexure 1A, to plan and formulate the LOCF for UG Physics courses of the University. The Steering Committee formed Subject Working Groups (Annexure 1B) to formulate the content of different sets of courses. The Subject Working Groups included teachers from more than twenty colleges of the University, who have experience of teaching the respective courses. About eighty faculty members from the Department of Physics and Astrophysics and Physics Departments of colleges of the University have contributed to this important task. The inputs of the Subject Working Groups were compiled, and the present document prepared by a final drafting team (Annexure 1C).

The University of Delhi offers the undergraduate B.Sc. (Honours) Physics programme, the B.Sc. Physical Sciences programme with Physics and Electronics disciplines, as well as general elective courses in Physics for students of Honours programme in disciplines other than Physics. The LOCF has been prepared for all of the above.

An earlier draft of the LOCF of the University of Delhi was put in the public domain for stakeholders' comments in May 2019. This was a revised version of the existing Choice Based Credit System (CBCS) undergraduate programme at the University of Delhi. We thank the stakeholders who took time and made effort to give us feedback on the earlier draft. Many of the comments received have helped us improve the LOCF draft.

We acknowledge the use of the document "Learning Outcomes based Curriculum Framework (LOCF) for Undergraduate Programme B.Sc. (Physics) 2019" put up by the UGC on its website in May 2019 (https://www.ugc.ac.in/pdfnews/1884134_LOCF-Final_Physics-report.pdf) and prepared by its Subject Expert Committee for Physics. This document has helped in clarifying the features of the LOCF and is the original source of a significant part of the text of the present document.

Keywords

Ability Enhancement Compulsory Course (AECC);

Core Courses (CC);

Discipline Specific Electives (DSE);

Learning Outcome-based Curriculum Frame work (LOCF);

Course Learning Outcomes (CLO);

Program Learning Outcomes (PLO);

Skill Enhancement Courses (SEC);

Teaching Learning Processes (TLP).

Learning Outcomes-Based Curriculum Framework for Undergraduate Education in Physics

1. INTRODUCTION

The learning outcomes-based curriculum framework for a B.Sc degree in Physical Sciences is intended to provide a comprehensive foundation to the subject, and to help students develop the ability to successfully continue with further studies and research in the subject. The framework is designed to equip students with valuable cognitive abilities and skills so that they are successful in meeting diverse needs of professional careers in a developing and knowledge-based society. The curriculum framework takes into account the need to maintain globally competitive standards of achievement in term of the knowledge and skills in Physics, as well develop scientific orientation, enquiring spirit, problem solving skills and values which foster rational and critical thinking.

Due to the extreme diversity of our country, a central university like the University of Delhi gets students from very different academic backgrounds, regions and language zones. While maintaining high standards, the learning outcome-based curriculum provides enough flexibility to teachers and colleges to respond to diverse needs of students.

The learning outcome-based curriculum framework for undergraduate courses in Physics also allows for flexibility and innovation in the programme design to adopt latest teaching and assessment methods, and include introduction to news areas of knowledge in the fast-evolving subject domains. The process of learning is defined by the following steps which form the basis of final assessment of the achievement at the end of the program.

(i) Development of an understanding and knowledge of basic Physics. This involves exposure to basics facts of nature discovered by Physics through observations and experiments. The other core component of this development is introduction to physics concepts and principles, their theoretical relationships in laws of physics, and deepening of their understanding via appropriate problems.

(ii) The ability to use this knowledge to analyze new situations and learn skills and tools like laboratory techniques, computational methods, and applied mathematics to find solution, interpret results and make meaningful predictions.

(iii) The ability to synthesize the acquired knowledge and experience for an improved comprehension of the physical problems and to create new skills and tools for their possible solutions.

2.LEARNING OUTCOME-BASED CURRICULUM FRAMEWORK IN B.Sc. PHYSICAL SCIENCES PROGRAMME

Note: There are three physical science courses namely PCM (Physics, Chemistry, Maths), PEM (Physics, Electronics, Maths), PMC (Physics, Maths, Computer) part where physics is of it.

2.1 NATURE AND EXTENT OF THE PROGRAMME IN B.Sc. PHYSICAL SCIENCES

The UG programs in Physics builds on the basic Physics taught at the +2 level in all the schools in the country. Ideally, the +2 senior secondary school education should aim and achieve a sound grounding in understanding the basic Physics with sufficient content of topics from modern Physics and contemporary areas of exciting developments in physical sciences. The curricula and syllabi should be framed and implemented in such a way that the basic connection between theory and experiment and its importance in understanding Physics is made clear to students. This is very critical in developing a scientific temperament and the urge to learn and innovate in Physics and other sciences. Unfortunately, the condition of our school system in most parts of the country lacks the facilities to achieve the above goal, and it is incumbent upon the college/university system to fill gaps in the scientific knowledge and understanding of our country's youth who complete school curricula and enter university education.

Physics is an experimental and theoretical science that studies systematically the laws of nature operating at length scales from the sub-atomic domains to the entire universe. The scope of Physics as a subject is very broad. The core areas of study within the disciplinary/subject area of an UG programme in Physics are: Classical and Quantum Mechanics, Electricity and Magnetism, Thermal and Statistical Physics, Wave theory and Optics, Physics of the Materials, Digital Electronics, and specialized methods of Mathematical Physics and their applications in different branches of the subject. Along with the theoretical course work students also learn physics laboratory methods for different branches of physics, specialized measurement techniques, analysis of observational data, including error estimation, and scientific report writing. The latest domain in Physics pedagogy incorporated in the LOCF framework is computational physics, which involves adaptation of Physics problems for algorithmic solutions, modelling and simulation of physical phenomenon and mastery of computer programming. The elective modules of the framework offer students choice to gain knowledge and expertise in more specialized domains of Physics like Nuclear and Particle physics, Nanophysics, Astronomy and Astrophysics, etc. and interdisciplinary subject areas like Biophysics, Geophysics, Environmental Physics, Medical Physics, etc.

The physics-based knowledge and skills learnt by students also equip them to be successful in careers other than research and teaching in Physics.

2.2 AIMS OF BACHELOR'S DEGREE PROGRAMME IN B.Sc. PHYSICAL SCIENCES

The LOCF based UG educational program in Physics aims to

- create the facilities and learning environment in educational institutions to consolidate the knowledge acquired at +2 level, motivate students to develop a deep interest in Physics, and to gain a broad and balanced knowledge and understanding of physical concepts, principles and theories of Physics.
- provide opportunities to students to learn, design and perform experiments in lab, gain an understanding of laboratory methods, analysis of observational data and report writing, and acquire a deeper understanding of concepts, principles and theories learned in the classroom through laboratory demonstration, and computational problems and modelling.
- develop the ability in students to apply the knowledge and skills they have acquired to get to the solutions of specific theoretical and applied problems in Physics.
- to prepare students for pursuing the interdisciplinary and multidisciplinary higher education and/or research in interdisciplinary and multidisciplinary areas, as Physics is among the most important branches of science necessary for interdisciplinary and multidisciplinary research.
- to prepare students for developing new industrial technologies and theoretical tools for applications in diverse branches of the economic life of the country, as Physics is one of the branches of science which contribute directly to technological development; and it has the most advanced theoretical structure to make quantitative assessments and predictions, and
- in light of all of the above to provide students with the knowledge and skill base that would enable them to undertake further studies in Physics and related areas, or in interdisciplinary/multidisciplinary areas, or join and be successful in diverse professional streams including entrepreneurship.

3. GRADUATE ATTRIBUTES IN B.Sc. PHYSICAL SCIENCES

Some of the characteristic attributes of a graduate in Physics are

- **Disciplinary knowledge**
  - (i) comprehensive knowledge and understanding of major concepts, theoretical principles and experimental findings in Physics and its different subfields like Mathematical Physics, Classical and Quantum mechanics, Thermal and Statistical mechanics, Electricity, Magnetism and Electromagnetic theory, Atomic and Molecular Physics, Condensed matter Physics, Nuclear and Particle Physics, Material Science, Analytical dynamics, Astrophysics and Cosmology, Space science and other related fields of study, including broader interdisciplinary subfields like Chemistry, Mathematics, Life sciences, Environmental sciences, Earth Sciences, Medical Physics, Atmospheric Physics, Computer science, Information Technology etc..
  - (ii) ability to use physics laboratory methods and modern instrumentation for designing and implementing new experiments in physics, interdisciplinary/multidisciplinary research areas and industrial research.
- **Skilled communicator:** Ability to transmit abstract concepts and complex information relating to all areas in Physics in a clear and concise manner through scientific report writing. Ability to express complex relationships and information through graphical

methods and proper tabulation. Ability to explain complex processes through simulation and modelling. Ability to express complex and technical concepts orally in a simple, precise and straightforward language for better understanding.

- **Critical thinking:** Ability to distinguish between relevant and irrelevant facts and information, discriminate between objective and biased information, apply logic to arrive at definitive conclusions, find out if conclusions are based upon sufficient evidence, derive correct quantitative results, make rational evaluations, and arrive at qualitative judgments according to established rules.
- **Sense of inquiry:** Capability for asking relevant/appropriate questions relating to the issues and problems in the field of Physics. Planning, executing and reporting the results of theoretical or experimental investigation.
- **Team player/worker**: Capable of working effectively in diverse teams in both classroom, laboratory, Physics workshop and in field-based situation.
- **Skilled project manager:** Capable of identifying/mobilizing appropriate resources required for a project, and managing a project through to completion, while observing responsible and ethical scientific conduct, safety and laboratory hygiene regulations and practices.
- **Digitally Efficient*:*** Capable of using computers for computational and simulation studies in Physics. Proficiency in appropriate software for numerical and statistical analysis of data, accessing and using modern e-library search tools like - to locate, retrieve, and evaluate Physics information from renowned physics archives, accessing observational and experimental data made available by renowned research labs for further analysis.
- **Ethical awareness/analytical reasoning*:*** The graduate should be capable of demonstrating the ability to think and analyze rationally with modern and scientific outlook and adopt objectives, which are unbiased and truthful in all aspects of work. She/he should be capable of ~~i~~identifying ethical issues related to one's work. She/he should be ready to appropriately acknowledge, direct and indirect contributions received from all sources, including from other personnel in the work field. Willing to contribute to the free development of knowledge in all forms. Further, unethical behavior such as fabrication, falsification or misrepresentation of data, or committing plagiarism, or not adhering to intellectual property rights should be avoided.
- **Social, National and International perspective*:*** The graduates should be able to develop a social perspective about the significance of their knowledge and skills for social well-being and a sense of responsibility towards human society and the planet. They should have a national as well as an international perspective for their work and career in the chosen field of academic and research activities.
- **Lifelong learners:** Capable of self-paced and self-directed learning aimed at personal development and for improving knowledge/skill development and reskilling in all areas of Physics.

4. QUALIFICATION DESCRIPTORS FOR GRADUATES IN B.Sc. PHYSICAL SCIENCES

The qualification descriptors for a B.Sc. Physical science program with combinations PCM, PEM or PMC may include the following:

The graduates should be able to demonstrate:

(i) a systematic and coherent understanding of basic physics including the concepts, theories and relevant experimental techniques in the domains of Mechanics, Thermal Physics, Electricity and Magnetism, Modern Physics, Optics, Mathematical Physics and of the specialized field like Nuclear and Particle Physics, Quantum Physics, Embedded Systems, etc. in their choice of Discipline Specific Elective course.

(ii) ability to relate their understanding of physics to other subjects like Mathematics, Chemistry, Computer Science or Electronics, which are part of their curriculum, and hence orient their knowledge and work towards multi-disciplinary/inter-disciplinary contexts and problems.

(iii) procedural knowledge that creates different types of professionals related to different areas of study in Physics and multi/interdisciplinary domains, including research and development, teaching, technology professions, and government and public service.

(iv) skills in areas related to specializations, relating the subfields and current developments in the field of Physics.

Use knowledge, understanding and skills required for identifying problems and issues relating to Physics, and its interface with other subjects studied in the course, collect relevant quantitative and/or qualitative data from a wide range of sources from various research laboratories of the world, their application, analysis and evaluation using appropriate methodologies.

Communicate the results of studies undertaken accurately in a range of different contexts using the main concepts, constructs and techniques of Physics and other subjects studied in the course. Develop communication abilities to present these results in technical as well as popular science meetings.

Ability to meet their own learning needs, drawing on a range of pedagogic material available on the internet and books, current research and development work and professional materials, and interaction with other science professionals.

Demonstrate Physics-related technological skills that are relevant to Physics-related trades and employment opportunities.

Apply their knowledge, understanding and skills to new/unfamiliar contexts beyond Physics to identify and analyze problems and issues, and to solve complex problems.

5. PROGRAM LEARNING OUTCOMES IN B.Sc. PHYSICAL SCIENCES WITH COMBINATIONS PCM, PEM or PMC

The student graduating with the Degree B.Sc. Physical sciences with PCM, PEM, or PMC should have:

(i) a systematic and coherent understanding of basic physics including the concepts, theories and relevant experimental techniques in the domains of Mechanics, Thermal Physics, Electricity and Magnetism, Modern Physics, Optics, Mathematical Physics and of the specialized field like Nuclear and Particle Physics, Quantum Physics, Embedded Systems, etc. in their choice of Discipline Specific Elective course.

(ii) a wide ranging and comprehensive experience in physics laboratory methods in experiments related to mechanics, optics, thermal physics, electricity, magnetism, digital electronics, solid state physics and modern physics. Students acquire the ability for systematic observations, use of scientific research instruments, analysis of observational data, making suitable error estimates and scientific report writing.

(iii) procedural knowledge that creates different types of professionals related to the disciplinary/subject area of Physics and multi/interdisciplinary domains, including professionals engaged in research and development, teaching, technology professions and government/public service.

(iv) skills in areas related to one's specialization area within the disciplinary/subject area physics.

Demonstrate the ability to use skills in Physics and its related areas of technology for formulating and solving problems and identifying and applying appropriate physical principles and methodologies to solve a wide range of problems associated with Physics and its interface with other subjects studied in the course.

Recognize the importance of mathematical modeling, simulation and computational methods, and the role of approximation and mathematical approaches to describing the physical world and beyond.

Plan and execute experiments or investigations related to Physics and its interface with other subjects studied in the course analyze and interpret data/information collected using appropriate methods, including the use of appropriate software such as programming languages and purpose-written packages, and report accurately the findings of the experiment/investigations while relating the conclusions/findings to relevant theories.

Demonstrate relevant generic skills and global competencies such as (i) problem-solving skills that are required to solve different types of Physics related problems with well-defined solutions, and tackle open-ended problems that belong to the disciplinary-area boundaries; (ii) investigative skills, including skills of independent investigation of problems; (iii) communication skills involving the ability to listen carefully, to read texts and research papers analytically and to present complex information in a concise manner to different groups/audiences of technical or popular nature; (iv) analytical skills involving paying attention to detail and ability to construct logical arguments, using correct technical language and ability to translate them with popular language when needed; (v) ICT skills; (vi) personal skills such as the ability to work both independently and in a group.

Demonstrate professional behavior such as

(i) being objective, unbiased and truthful in all aspects of work and avoiding unethical, irrational behavior 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 its universal appeal for the entire humanity;
(iv) appreciation of intellectual property, environmental and sustainability issues; and promoting safe learning and working environment.

6. TEACHING LEARNING PROCESSES

The teaching learning processes play the most important role in achieving the desired aims and objectives of the undergraduate programs in Physics. The LOCF framework emphasizes learning outcomes for every physics course and its parts. This helps in identifying most suitable teaching learning processes for every segment of the curricula. Physics is basically an experimental science with a very elaborate and advanced theoretical structure. Systematic observations of controlled experiments open up windows to hidden properties and laws of nature. Physics concepts and theories are meant to create a systematic understanding of these properties and laws. All principles and laws of physics are accepted only after their verification and confirmation in laboratory, or observations in the real world, which require scientists trained in appropriate experimental techniques, and engineers to design and make advanced scientific instruments. At the same time physics graduates also need a deep understanding of physics concepts, principles and theories, which require familiarity with different branches of mathematical physics. To achieve these goals, the appropriate training of young individuals to become competent scientists, researchers and engineers in future has to be accomplished. For this purpose, a very good undergraduate program in Physics is required as a first step. An appropriate teaching-learning procedure protocol for all the colleges is therefore essential. To be specific, it is desirable to have:

- Sufficient number of teachers in permanent position to do all the class room teaching and supervise the laboratory experiments to be performed by the students.
- All teachers should be qualified as per the UGC norms and should have good communication skills.
- Sufficient number of technical and other support staff to run laboratories, libraries, and other equipment and to maintain the infrastructural facilities like buildings, ICT infrastructure, electricity, sanitation, etc.
- Necessary and sufficient infrastructural facilities for the class rooms, laboratories and libraries.
- Modern and updated laboratory equipment needed for the undergraduate laboratories and reference and text books for the libraries.
- Sufficient infrastructure for ICT and other facilities needed for technology enabled learning like computer facilities, PCs, laptops, Wi-Fi and internet facilities with all the necessary software.

Teachers should make use of these approaches for an efficient teaching-learning process:

(i) Class room teaching with lectures using traditional as well as electronic boards.

(ii) Demonstration of the required experiments in laboratory and sessions on necessary apparatuses, data analysis, error estimation and scientific report writing for effective and efficient learning of laboratory techniques.

(iii) Imparting the problem solving ability which enables a student to apply physical and mathematical concepts to a new and concrete situation is essential to all courses. This can be accomplished through examples discussed in the class or laboratory, assignments and tutorials.

(iv) CBCS curriculum has introduced a significant content of computational courses. Computational physics should be used as a new element in the physics pedagogy, and efforts should be made to introduce computational problems, including simulation and modelling, in all courses.

(v) Teaching should be complimented with students seminar to be organized very frequently.

(vi) Guest lectures and seminars should be arranged by inviting eminent teachers and scientists.

(vii) Open-ended project work should be given to all students individually, or in groups of 2-3 students depending upon the nature of the course.

(viii) Since actual Undergraduate programme teaching is done in affiliated colleges which have differing levels of infrastructure and student requirements, the teachers should attend workshops organized by University Department for college faculty on teaching methodology, reference materials, latest laboratory equipment and experiments, and computational physics software for achieving uniform standards. Common guidelines for individual courses needs to be followed/evolved.

(ix) Internship of duration varying from one week anytime in the semester, and/or 2-6 weeks during semester break and summer breaks should be arranged by the college for the students to visit other colleges/universities/HEI and industrial organizations in the vicinity. If needed, financial assistance may also be provided for such arrangements.

(x) Special attempts should be made by the institution to develop problem-solving skills and design of laboratory experiments for demonstration at the UG level. For this purpose a mentor system may be evolved where 3-4 students may be assigned to each faculty member.

(xi) Teaching load should be managed such that the teachers have enough time to interact with the students to encourage an interactive/participative learning.

In the first year students are fresh from school. Given the diversity of their backgrounds, and the lack of adequate infrastructure and training in the school science learning, special care and teacher attention is essential in the first year. Mentorship with senior students and teachers can help them ease into rigorous of university level undergraduate learning.

A student completing the Physical Sciences with Physics discipline course under the CBCS takes 4 core courses from each discipline, 2 discipline specific electives (DSE) courses in each discipline, 4 skill enhancement (SEC) courses including at least one from each discipline and two ability enhancement compulsory courses (AECC). Since different categories of courses have different objectives and intended learning outcomes, the most efficient and appropriate teaching learning processes would not be same for all categories of courses.

6.1 TEACHING LEARNING PROCESSES FOR CORE COURSES

The objective of Core courses is to build a comprehensive foundation of physics concepts, principles and laboratory skills so that a student is able to proceed to any specialized branch. Rather than a quantitative amalgamation of disparate knowledge, it is much more preferable that students gain the depth of understanding and ability to apply what they have learnt to diverse problems.

All Core courses have a theory and an associated physics laboratory component. Even though the learning in theory and lab components proceeds in step, the teaching learning processes for the two components need specific and different emphases.

6.1.1 Teaching Learning Processes for Theory component of Core Courses

A significant part of the theoretical learning in core courses is done in the traditional lecture cum black-board method. Demonstrations with models, power-point projection, student project presentations, etc. are some other methods which should be judiciously used to enhance the learning experience. Problem solving should be integrated into theoretical learning of core courses and proportionally more time should be spent on it. It is advisable that a list of problems is distributed to students before the discussion of every topic, and they are encouraged to solve these in the self-learning mode, since teachers are unlikely to get time to discuss all of them in the class room.

6.1.2 Teaching Learning Processes for Physics Laboratory component of Core Courses

Students learn essential physics laboratory skills mainly while preparing for experiments, performing them in the laboratory, and writing appropriate laboratory reports. Most of this learning takes place in the self-learning mode. However, teachers' role is crucial at critical key points. Physics laboratory learning suffers seriously if students do not get appropriate guidance at these key points. Many students get their first proper exposure to physics laboratory work in their first year of undergraduate studies. Hence, laboratory teaching to first year students requires special care.

Demonstration on the working of required apparatuses should be given in few beginning laboratory sessions of all courses. Sessions on the essentials of experimental data analysis, error estimation, and scientific report writing are crucial in the first year physics laboratory teaching. Once the essentials have been learnt, sessions may be taken on applications of these for specific experiments in lab courses of later years. Students should be encouraged to explore experimental physics projects outside the curricula.

Many college laboratories lack latest laboratory equipment due to resource crunch. For example, very few laboratories have equipment for sensor and microprocessor based data acquisition, whose output can be directly fed into a computer for further analysis. Colleges need to make strategic planning, including student participation under teacher guided projects, to gradually get their laboratories equipped with latest equipment. The Physics department of the University can provide key guidance and help in this regard.

It is recommended that the maximum size of group for all Physics laboratory courses should be 12-15 students per group.

6.2 TEACHING LEARNING PROCESSES FOR DISCIPLINE SPECIFIC ELECTIVES

The objective of DSE papers is to expose students to domain specific branches of physics and prepare them for further studies in the chosen field. While students must learn basic theoretical concepts and principles of the chosen domain, a sufficient width of exposure to diverse topics is essential in these papers. Student seminars and projects can be a very fruitful way to introduce students to the latest research level developments.

Besides a theory component, every DSE paper has either an associated tutorial, or a physics laboratory, or a computational physics component. Teaching learning processes for theory and physics laboratory components described above in sub-sections 6.1.1and 6.1.2 for core courses, should be applicable for DSE courses too.

Essential programming skills are the foremost requirement of **computational physics learning**. The second requirement of computational physics learning is the ability to transform a physics problem into a computable problem for which a suitable programme can be written. Appropriate problems based assignments are crucial in developing these abilities. Every computational physics lab course should involve sessions on essential computational techniques, and the reduction of relevant physics problems to computational problems. Advanced level student project can be easily integrated into the learning of computational physics.

Colleges should ensure that students from weaker economic backgrounds have adequate access to computers.

Tutorials provide an opportunity for attending closely to learning issues with individual students, and hence an effective means to help create interest in the subject and assess their understanding. Pre-assigned weekly problem sets and assignments help structure tutorial sessions and should be used as often as possible. Students' performance in tutorials should be used for determining their internal assessment marks for the course.

It is recommended that the maximum size of group for all tutorials should be 8-10 students per group.

6.3 TEACHING LEARNING PROCESSES FOR SKILL ENHANCEMENT COURSES

Skill Enhancement papers are intended to help students develop skills which may or may not be directly applicable to physics learning. These courses introduce an element of diversity of learning environments and expectations. Efforts should be made that students gain adequate ‘hands-on’ experience in the desired skills. The theory parts of these courses are intended to help students get prepared for such experiences. Since the assessment of these courses is largely college based, teachers should make full use of it to design novel projects.

It is recommended that the maximum size of group in the laboratory for all SEC courses should be 12-15 students per group.

At the end, the main purpose of Physics teaching should be to impart higher level objective knowledge to students in concrete, comprehensive and effective ways. Here, effectiveness implies gaining knowledge and skill which can be applied to solve practical problems as well as attaining the capability of logical thinking and imagination which are necessary for the creation of new knowledge and new discoveries. Once the students understand ‘why is it worth learning?’ and ‘how does it connect to the real world?’, they will embrace the curriculum in a way that would spark their imagination and instill a spirit of enquiry in them, so that in future they can opt for further investigations or research. All in all, the teacher should act as a facilitator and guide and not as a guardian of the curriculum.

7. ASSESSMENT METHODS

In the undergraduate education of Physics leading to the B.Sc. Physical Science degree, the assessment and evaluation methods should focus on testing the conceptual understanding of basic concepts and theories, experimental techniques, development of mathematical skills, and the ability to apply the knowledge acquired to solve new problems and communicate the results and findings effectively.

The two perennial shortfalls of the traditional science examination process in our country are the reliance on rote learning for written exams, and a very perfunctory evaluation of laboratory skills. Greater emphasis on problem solving and less importance to textbook derivations discourages rote learning. Theory examinations should be based primarily on unseen problems. Continuous evaluation of students’ work in the laboratory, and testing them on extensions of experiments they have already performed can give a more faithful evaluation of their laboratory skills.

Needless to say, there should be a continuous evaluation system for students. This will enable teachers not only to ascertain the overall progress of learning by the students, but also to identify students who are slow learners and for whom special care should be taken. An appropriate grading system is the ‘relative grading system’. It introduces a competitive element among students, but does not excessively penalizes weaker students.

Since the Learning Objectives are defined clearly for each course in the LOCF framework, it is easier to design methods to monitor the progress in achieving the learning objectives during the course and test the level of achievement at the end of the course.

The courses offered in the undergraduate Physics are the first courses at the college/university level. Formative Assessment for monitoring the progress towards achieving the learning objectives is an important assessment component, which provides both teachers and students feedback on progress towards learning goals. University of Delhi examination system has 20 percent internal assessment for theory component, and 50 percent for physics laboratory and computational physics laboratory components. These marks should be distributed in periodic assessments in different modes to serve the intended purpose

Since core courses, discipline specific courses, skill enhancement courses and general elective courses have qualitatively different kinds of objectives and learning outcomes, one model of assessment methods will not work for these different kinds of courses.

7.1 ASSESSMENT METHODS FOR CORE COURSES

Core courses and associated physics laboratory and computational physics curricula lead to the essential set of learning outcomes, which every physics graduate is expected to have. Their assessment methods require rigor, comprehensiveness and uniformity about what is minimally expected from students. Regular interactions mediated through university department among teachers teaching these courses in different colleges may prove to be helpful in this regard. Since depth of understanding of core topics is a highly desirable outcome, assessment for these courses should put greater emphasis on unseen problems, including extensions of textbook derivations done in class.

7.1.1 Assessment Methods for the Theory component of Core courses

The evaluation scheme of the University of Delhi allots 20 percent marks for internal assessment of theory papers. Teachers should use a judicious combination of the following methods to assess students for these marks: i) periodic class tests, ii) regular problem based assignments, iii) unannounced short quizzes, iv) individual seminar presentations v) longer assignments for covering theory and derivations not discussed in regular lectures, vi) True/False Tests, and vii) Multiple Choice Tests for large classes.

To help students prepare themselves for formative assessment during the semester, and to motivate them for self-learning, it is advisable that a Model Problem Set is made available to them in the beginning of the course, or problem sets are given before discussion of specific topics in class.

In preparing students for Substantive Summative Assessment at the end of the semester it is helpful if a Model/mock question paper is made available to them in the beginning of the course.

7.1.2 Assessment Methods for the Physics Laboratory component of Core courses

The 50 percent internal assessment for the evaluation scheme for laboratory courses is best used in continuous evaluation of students' performance in the lab. This evaluation should include these components: i) Regular evaluation of experiments regarding a) written report of each experiment and b) Viva-Voce on each experiment, ii) Test through setting experiments by assembling components, iii) written test on experiments done in the lab and data analysis, iv) Designing innovative kits to test the comprehension and analysis of the experiment done by the students, and v) audio visual recording of the experiments being performed by students and its self-appraisal.

The end semester laboratory examination should ideally involve extensions of experiments done by students during the semester. Two or more experiments can be combined for this purpose. Open ended problems for which students can get the answer by designing their own experimental method should also be tried.

7.2 ASSESSMENT METHODS FOR DISCIPLINE SPECIFIC ELECTIVES

Discipline specific courses build upon general principles learnt in core courses, and also prepare students for further studies in specific domains of physics. Given the time constraint of only one semester, specific domain exposure is mostly introductory in character. Assessment for these courses should have significant component of open ended methods like seminars and project work. Students have greater chance of proving their individual initiative and ability for self-learning in these methods. These methods also have greater flexibility to reward students for out of curriculum learning.

Besides a theory component, every DSE paper has either an associated tutorial, or a physics laboratory, or a computational physics component. Assessment methods for theory and physics laboratory components described above in sub-sections 7.1.1 and 7.1.2 for core courses, should be applicable for DSE courses too.

Computational Physics lab evaluation allots 50 percent marks to the internal evaluation of students' performance during the semester. Students should be assessed for every computational assignment done during the semester. This should involve assessment of their programme, report and a viva-voice. Periodic tests on unseen problems may form a part of the internal assessment. It is essential that the end semester examination is based upon unseen computational physics problems.

Students should be assessed for their performance in **tutorials**, and this assessment should contribute to their internal assessment marks. Their work on pre-assigned problem sets/assignments, and participation in tutorial discussions should be taken into account while assessing their performance.

7.3 ASSESSMENT METHODS FOR SKILL ENHANCEMENT COURSES

Learning in skill enhancement courses is largely experience based. Student performance in these courses is best assessed under continuous evaluation. Students could be assigned a specific task for a class or group of classes, and they could be assessed for their success in meeting the task.

8. STRUCTURE OF COURSES IN B.Sc. PHYSICAL SCIENCES

8.1 Credit Distribution for B.Sc. Physical Sciences (with PCM, PMC and PEM).

The B.Sc. Physical science programme with Physics as one of the subjects consists of 132 credits based on the Choice Based Credit System (CBCS) approved by the UGC with 01 hour/week for each credit for theory/tutorials and 02 hours/week for each credit of laboratory work/Hands-on exercises. Out of 132 credits, 108 credits are of Core and DSE courses equally divided between Physics and two other subjects (36 credits each), 16 credits consist of Skilled Enhancement courses (SEC) which are elective and 8 credits consists of Ability Enhancement Compulsory Courses (AECC) equally divided (4 credits each) between disciplines of the Environmental sciences and Languages/communications. A student can take more than 132 credits in total (but not more than 148 credits) to qualify for the grant of the B.Sc. Physical Sciences degree as per rules and regulations of the University.

Table 8.1 Table showing distribution of credits: Subject A: Physics Discipline, Subject B and C (other two disciplines)

Semester	Compulsory Core Courses (CC) each with 06 credit (Total no. of Papers 12) 04 Core courses are compulsory to be selected from	Discipline Specific Elective (DSE) each with 06 credits, Select any 02 courses from each subject A B and C	Ability Enhancement Compulsory Courses (AECC) each with 04 credits, Select any 02 from 03	Skill Enhancement Course (SEC) each with 04 credits, Select any 04 courses choosing at least 1 from each subject	Total Credits
Sem I	CC-1A CC-1B CC-1C	-	AECC-1	-	22
Sem II	CC-2A CC-2B CC-2C	-	AECC-2	-	22
Sem III	CC-3A CC-3B CC-3C	-	-	SEC-1(A/B/C)	22
Sem IV	CC-4A CC-4B CC-4C	-	-	SEC-2(A/B/C)	22
Sem V	-	DSE-1A DSE -1B DSE -1C	-	SEC-3(A/B/C)	22
Sem VI	-	DSE -2A DSE -2B DSE -2C	-	SEC-4(A/B/C)	22
Total Credits	**72**	**36**	**8**	**16**	**132**

Table 8.2 DETAILS OF COURSES UNDER UNDERGRADUATE PROGRAMME (B.Sc. Physical Science)

Course **#Credits**

Theory + Practical/Tutorials

===

I. Core Course 12 X (4+2)* = 72
(12 Papers)

04 Courses from each of the

03 disciplines of choice

II. DSE Courses 6 X (4+2)* or 6 X (5+1)** =36

(6 Papers)

Two papers from each discipline of choice including paper of interdisciplinary nature.

Optional Dissertation or project work in place of one Discipline elective paper (6 credits) in 6th Semester

III. AECC Courses 2 X 4 = 8

(2 Papers of 2 credits each) Environmental Science English/MIL Communication

IV. SEC Courses 4 X (2+2)* =16

(4 Papers of 2 credits each)

Total credit = 132

College should evolve a system/policy about ECA/Interest/Hobby/ Sports/NCC/ NSS/related courses on its own.

***Theory with practical/ Hands-on Exercise**
****Theory with tutorials**
#Wherever there is practical there will be no tutorials and vice -versa. The size of group for practical papers is recommended to be a maximum of 12 to 15 students and for tutorials 8-10 students per group.

8.2 SEMESTER-WISE DISTRIBUTION OF COURSES

CORE COURSES (CC)

Table 8.3 All CC courses of Physics Discipline (Subject-A) have 6 credits with 4 credits of theory and 2 credits of practicals:

Core Course type	Unique Paper Code	Semester	B.Sc.(PCM)	B.Sc. (PEM)	B.Sc. (PMC)
CC-1A	42221101	I	Mechanics + Lab	Mechanics + Lab	Mechanics + Lab
CC-2A	42221201	II	Electricity, Magnetism and EMT + Lab	Electricity, Magnetism and EMT + Lab	Electricity, Magnetism and EMT + Lab
CC-3A	42224303	III	Thermal Physics and Statistical Mechanics + Lab	Thermal Physics and Statistical Mechanics+ Lab + Lab	Thermal Physics and Statistical Mechanics + Lab
CC-4A	42224412	IV	Waves and Optics + Lab	Waves and Optics + Lab	Waves and Optics + Lab

DISCIPLINE SPECIFIC ELECTIVES (DSE)

Table 8.4 All DSE courses of Physics Discipline (Subject-A) have 6 credits with 4 credits of theory and 2 credits of practical or 5 credits of theory and 1 credit of Tutorials.

Discipline Specific (Subject-A: Physics) Elective papers (Credit: 06 each) (DSE 1A and DSE 2A): Select any 02 papers (one for each in semester V and semester IV) from the following options. **(Numbers in brackets indicate number of hours/ Week dedicated)**

S. No.	Unique Paper Code	B.Sc.(PCM)	B.Sc. (PEM)	B.Sc. (PMC)
Odd Semester – V Semester only (DSE-1A)				
1	42227529	Elements of Modern Physics (4) + Lab (4)	Elements of Modern Physics (4) + Lab (4)	Elements of Modern Physics (4) + Lab (4)
2	42227530	Digital, Analog and Instrumentation (4) + Lab (4)	Digital, Analog and Instrumentation (4) + Lab (4)	Digital, Analog and Instrumentation (4) + Lab (4)
3	42227531	Mathematical Physics (4) + Lab (4)	Mathematical Physics (4) + Lab (4)	Mathematical Physics (4) + Lab (4)
4	42227532	Nano Materials and Applications (4) + Lab (4)	Nano Materials and Applications (4) + Lab (4)	Nano Materials and Applications (4) + Lab (4)
5	42227533	Communication System (4) + Lab (4)	Communication System (4) + Lab (4)	Communication System (4) + Lab (4)
6	42227534	Verilog and FPGA based system design (4) + Lab (4)	Verilog and FPGA based system design (4) + Lab (4)	Verilog and FPGA based system design (4) + Lab (4)
7	42227535	Medical Physics (4) + Lab (4)	Medical Physics (4) + Lab (4)	Medical Physics (4) + Lab (4)
8	42227536	Applied Dynamics (4) + Lab (4)	Applied Dynamics (4) + Lab (4)	Applied Dynamics (4) + Lab (4)

Even Semester – VI semester only (DSE-2A)				
9	42227637	Solid State Physics (4) + Lab (4)	Solid State Physics (4) + Lab (4)	Solid State Physics (4) + Lab (4)
10	42227638	Embedded System: Introduction to microcontroller (4) + Lab (4)	Embedded System: Introduction to microcontroller (4) + Lab (4)	Embedded System: Introduction to microcontroller (4) + Lab (4)
11	42227639	Nuclear and Particle Physics (5) + Tutorials (1)	Nuclear and Particle Physics (5) + Tutorials (1)	Nuclear and Particle Physics (5) + Tutorial (1)
12	42227640	Quantum Mechanics (4) + Lab (4)	Quantum Mechanics (4) + Lab (4)	Quantum Mechanics (4) + Lab (4)
13	42227641	Digital Signal processing (4) + Lab (4)	Digital Signal processing (4) + Lab (4)	Digital Signal processing (4) + Lab (4)
14	42227642	Astronomy and Astrophysics (5) + Tutorials (1)	Astronomy and Astrophysics (5) + Tutorials (1)	Astronomy and Astrophysics (5) + Tutorials (1)
15	42227643	Atmospheric Physics (4) + Lab (4)	Atmospheric Physics (4) + Lab (4)	Atmospheric Physics (4) + Lab (4)
16	42227644	Physics of the Earth (5) + Tutorials (1)	Physics of the Earth (5) + Tutorials (1)	Physics of the Earth (5) + Tutorials (1)
17	42227645	Biological physics (5) + Tutorials (1)	Biological physics (5) + Tutorials (1)	Biological physics (5) + Tutorials (1)
18	------	Dissertation (8)	Dissertation (8)	Dissertation (8)

SKILL ENHANCEMENT COURSES (SEC)

Table 8.5 All SEC courses of Physics Discipline (Subject-A) have 4 credits with 2 credits of theory and 2 credits of Practical / Hands on/ Projects and Field Work to be decided by the College. *Teachers may give a long duration project based on a SEC paper in the practical Lab.*

No.	Unique Paper Code	Semester	B.Sc. (PCM)	B.Sc. (PEM)	B.Sc. (PMC)
1	32223901	III/IV/V/VI	Physics Workshop Skills	Physics Workshop Skills	Physics Workshop Skills
2	32223902	III/IV/V/VI	Computational Physics Skills	Computational Physics Skills	Computational Physics Skills
3	32223903	III/IV/V/VI	Electrical Circuit and Network Skills	Electrical Circuit and Network skills	Electrical Circuit and Network
4	32223904	III/IV/V/VI	Basic Instrumentation Skills	Basic Instrumentation Skills	Basic Instrumentation Skills
5	32223905	III/IV/V/VI	Renewable Energy and Energy Harvesting	Renewable Energy and Energy Harvesting	Renewable Energy and Energy Harvesting
6	32223906	III/IV/V/VI	Engineering design and prototyping/Technical Drawing	Engineering design and prototyping/Technical Drawing	Engineering design and prototyping/ Technical Drawing
7	32223907	III/IV/V/VI	Radiation Safety	Radiation Safety	Radiation Safety

8	32223908	III/IV/V/VI	Applied Optics	Applied Optics	Applied Optics
9	32223909	III/IV/V/VI	Weather Forecasting	Weather Forecasting	Weather Forecasting
10	XXX1	III/IV/V/VI	Introduction to Physical Computing	Introduction to Physical Computing	Introduction to Physical Computing
11	XXX2	III/IV/V/VI	Numerical Analysis	Numerical Analysis	Numerical Analysis

ABILITY ENHANCEMENT COMPULSORY COURSES (AECC)

Table 8.6 All the courses have 4 credits. The detailed content of these courses is NOT mentioned in this document.

S.No.	AECC Course Name
1	English
2	MIL Communication
3	Environmental Science

TABLE 8.7 SEMESTER-WISE BREAKUP OF TYPES OF COURSES WITH THEIR CREDITS. Subject A-Physics; Subject B and C (other two disciplines)

No.*	Course opted	Course name	Credits
I	Ability Enhancement Compulsory Course-I	English communications/ Environmental Science	4
	Core Course-1A	Mechanics (Theory + Lab)	4 + 2
	Core Course-1B	CC-1B	6
	Core Course-1C	CC-1C	6
II	Ability Enhancement Compulsory Course-II	English communications/ Environmental Science	4
	Core Course-2A	Electricity, Magnetism & EMT (Theory + Lab)	4 + 2
	Core Course-2B	CC-2B	6
	Core Course-2C	CC-2C	6
III	Core Course-3A	Thermal Physics & Statistical Mechanics (Theory + Lab)	4 + 2
	Core Course-3B	CC-3B	6
	Core Course-3C	CC-3C	6
	Skill Enhancement Course -1	SEC-1 (A/B/C)	4
IV	Core Course-4A	Waves and Optics (Theory + Lab)	4 + 2
	Core Course-4B	CC-4B	6
	Core Course-4C	CC-4C	6
	Skill Enhancement Course -2	SEC-2 (A/B/C)	4
V	Discipline Specific Elective -1 A	DSE-1A (Subject A: Physics) See Table 8.4	6
	Discipline Specific Elective -1 B	DSE-1B (Subject B)	6
	Discipline Specific Elective -1 C	DSE-1C (Subject C)	6

	Skill Enhancement Course -3	SEC-3 (A/B/C)	4
VI	Discipline Specific Elective - 2 A	DSE-2A (Subject A: Physics) See Table 8.4	6
	Discipline Specific Elective - 2 B	DSE-2B (Subject B)	6
	Discipline Specific Elective - 2 C	DSE-2C (Subject C)	6
	Skill Enhancement Course - 4	SEC-4 (A/B/C)	4
		TOTAL	**132**

9. Detailed Courses for Programme in B.Sc. Physical Sciences, including Course Objectives, Learning Outcomes, and Readings

9.1. Core Courses

CC-1A: Mechanics (42221101)
Credit: 06 (Theory-04, Practical-02)
Theory: 60 Hours
Practical: 60 Hours

Course Objective

This course reviews the concepts of mechanics learnt at school from a more advanced perspective and goes on to build new concepts. It begins with Newton's Laws of Motion and ends with the Fictitious Forces and Special Theory of Relativity. Students will also appreciate the Rotational Motion, Gravitation and Oscillations.
The students will be able to apply the concepts learnt to several real world problems.

Course Learning Outcomes

Upon completion of this course, students are expected to understand the following concepts:

- Understand the role of vectors and coordinate systems in Physics, solve Ordinary Differential Equations, laws of motion and their application to various dynamical situations.
- Learn the concept of Inertial reference frames their transformations. Also, the concept of conservation of energy, momentum, angular momentum and apply them to basic problems.
- Understand the phenomena of elastic and in-elastic collisions, phenomenon of simple harmonic motion, understand angular momentum of a system of particle, understand concept of Geosynchronous orbits
- Understand special theory of relativity - special relativistic effects and their effects on the mass and energy of a moving object.
- In the laboratory course, after acquiring knowledge of how to handle measuring instruments (like screw gauge, Vernier calipers, travelling microscope) student shall embark on verifying various principles and associated measurable parameters.

Unit 1

Vectors: Vector algebra. Derivatives of a vector with respect to a parameter. Scalar and vector products of two, three and four vectors. Gradient, divergence and curl of vectors fields. Polar and Axial vectors.

(5 Lectures)

Ordinary Differential Equations: 1st order homogeneous differential equations, exact and non-exact differential equations, 2nd order homogeneous and non-homogeneous differential equations with constant coefficients (Operator Method Only).

(9 Lectures)

Unit 2

Laws of Motion: Review of Newton's Laws of motion. Dynamics of a system of particles. Concept of Centre of Mass, determination of center of mass for discrete and continuous systems having cylindrical and spherical symmetry (1-D, 2-D, 3-D objects).

(6 Lectures)

Work and Energy: Motion of rocket. Work-Energy theorem for conservative forces. Force as a gradient of Potential Energy. Conservation of momentum and energy. Elastic and in-elastic Collisions.

(4 Lectures)

Unit 3

Rotational Dynamics: Angular velocity, Angular momentum, Torque, Conservation of angular momentum, Moment of Inertia. Theorem of parallel and perpendicular axes (statements only). Calculation of Moment of Inertia of discrete and continuous objects (1-D, 2-D and 3-D). Kinetic energy of rotation. Motion involving both translation and rotation.

(8 Lectures)

Unit 4

Gravitation: Newton's Law of Gravitation. Motion of a particle in a central force field (motion is in a plane, angular momentum is conserved, areal velocity is constant). Kepler's Laws (statements only). Satellite in circular orbit and applications. Geosynchronous orbits.

(4 Lectures)

Unit 5

Oscillations: Simple harmonic motion. Differential equation of SHM and its solutions. Kinetic and Potential Energy, Total Energy and their time averages. Compound pendulum. Differential equations of damped oscillations and forced oscillations and their solution.

(10 Lectures)

Unit 6

Special Theory of Relativity: Frames of reference. Gallilean Transformations. Inertial and Non-inertial frames. Outcomes of Michelson Morley's Experiment. Postulates of Special Theory of Relativity. Length contraction. Time dilation. Relativistic transformation of velocity. Relativistic variation of mass. Mass-energy equivalence. Transformation of Energy and Momentum.

(14 Lectures)

Note: Students are not familiar with vector calculus. Hence all examples involve differentiation either in one dimension or with respect to the radial coordinate.

PRACTICAL (60 Hours)
PHYSICS LAB: CC -1A LAB: Mechanics

Demonstration cum laboratory sessions on the construction and use of Vernier callipers, screw gauge and travelling microscope, and necessary precautions during their use.

Sessions and exercises on the least count errors, their propagation and recording in final result up to correct significant digits, linearization of data and the use of slope and intercept to determine unknown quantities.

Session on the writing of scientific laboratory reports, which may include theoretical and practical significance of the experiment performed, apparatus description, relevant theory, necessary precautions to be taken during the experiment, proper recording of observations, data analysis, estimation of the error and explanation of its sources, correct recording of the result of the experiment, and proper referencing of the material taken from other sources (books, websites, research papers, etc.)

At least 06 experiments from the following:

1. Measurements of length (or diameter) using Vernier calliper, screw gauge and travelling microscope.
2. To study the random error in observations.
3. To determine the height of a building using a Sextant.
4. To study the motion of the spring and calculate (a) Spring constant and, (b) g.
5. To determine the Moment of Inertia of a Flywheel.
6. To determine g and velocity for a freely falling body using Digital Timing Technique.
7. To determine Coefficient of Viscosity of water by Capillary Flow Method (Poiseuille's method).
8. To determine the Young's Modulus of a Wire by Optical Lever Method.
9. To determine the Modulus of Rigidity of a Wire by Maxwell's needle.
10. To determine the elastic constants of a wire by Searle's method.
11. To determine the value of g using Bar Pendulum.
12. To determine the value of g using Kater's Pendulum.

References for Theory

Essential Readings

1. Vector Analysis, Murray R. Spiegel et. al., 2/e, 2017, McGraw Hill Education.
2. Differential Equations, R. Bronson, G. B. Costa, 4/e, 2014, McGraw Hill Education.
3. Mechanics, D. S. Mathur, P. S. Hemne, 2012, S. Chand.
4. Intermediate Dynamics, Patrick Hamill, 2010, Jones and Bartlett Publishers.
5. Physics for Scientists and Engineers, R. A. Serway, J. W. Jewett, Jr, 9/e, 2014, Cengage Learning.

Additional Readings

1. Feynman Lectures, Vol. 1, R. P. Feynman, R. B. Leighton, M. Sands, 2008, Pearson Education.
2. University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.
3. University Physics, H. D. Young, R. A. Freedman, 14/e, 2015, Pearson Education.
4. Fundamentals of Physics, Resnick, Halliday & Walker 10/e, 2013, Wiley.
5. Engineering Mechanics, Basudeb Bhattacharya, 2/e, 2015, Oxford University Press.
6. Physics for Scientists and Engineers, Randall D Knight, 3/e, 2016, Pearson Education.
7. Physics: Principles with Applications, D. C. Giancoli, 6/e, 2005, Pearson Education.

Reference for Laboratory work

1. Advanced Practical Physics for students, B. L. Flint and H. T. Worsnop, 1971, Asia Publishing House.
2. Engineering Practical Physics, S. Panigrahi & B. Mallick, 2015, Cengage Learning India Pvt. Ltd.
3. Practical Physics, G. L. Squires, 2015, 4/e, Cambridge University Press.
4. A Text Book of Practical Physics, I. Prakash & Ramakrishna, 11/e, 2011, Kitab Mahal.
5. B. Sc. Practical Physics, Geeta Sanon, R. Chand, 2016.

CC-2A: Electricity, Magnetism & EMT (42221201)
Credit: 06 (Theory-04, Practical-02)
Theory: 60 Hours
Practical: 60 Hours

Course Objective

This course reviews the concepts of electromagnetism learnt at school from a more advanced perspective and goes on to build new concepts. The course covers static and dynamic electric and magnetic fields, and the principles of electromagnetic induction. It also includes analysis of electrical circuits and introduction of network theorems. The students will be able to apply the concepts learnt to several real world problems.

Course Learning Outcomes

At the end of this course, students will be able to

- Have basic knowledge of Vector Calculus

- Demonstrate Gauss law, Coulomb's law for the electric field, and apply it to systems of point charges as well as line, surface, and volume distributions of charges.
- Apply Gauss's law of electrostatics to solve a variety of problems. Articulate knowledge of electric current, resistance and capacitance in terms of electric field and electric potential.
- Calculate the magnetic forces that act on moving charges and the magnetic fields due to currents (Biot- Savart and Ampere laws)
- Have brief idea of magnetic materials, understand the concepts of induction, solve problems using Faraday's and Lenz's laws
- In the Lab course, students will be able to measure resistance (high and low), Voltage, Current, self and mutual inductance, capacitor, strength of magnetic field and its variation, study different circuits RC, LCR etc.

Unit 1

Vector Analysis: Review of vector algebra (Scalar and Vector product), Vector Integration, Line, surface and volume integrals of Vector fields, Gauss-divergence theorem and Stoke's theorem of vectors (statement only).

(10 Lectures)

Unit 2

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. Dielectric medium, Polarization, Displacement vector. Gauss's theorem in dielectrics. Parallel plate capacitor completely filled with dielectric.

(24 Lectures)

Unit 3

Magnetism:
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.

(10 Lectures)

Unit 4

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.

(6 Lectures)

Unit 5

Maxwell`s equations and Electromagnetic wave propagation: Equation of continuity of current, Displacement current, Maxwell's equations, Wave equation in free space.

(10 Lectures)

PRACTICAL (60 Hours)
PHYSICS LAB: CC-2A LAB: Electricity and Magnetism

Dedicated demonstration cum laboratory sessions on the construction, functioning and uses of different electrical bridge circuits, and electrical devices like the ballistic galvanometer.

Sessions on the review of scientific laboratory report writing, and on experimental data analysis, least square fitting, and computer programme to find slope and intercept of straight-line graphs of experimental data.

At least 06 experiments from the following:

1. To use a Multimeter for measuring (a) Resistances, (b) AC and DC Voltages, (c) DC Current, and (d) checking electrical fuses.
2. Ballistic Galvanometer:
   (i) Measurement of charge and current sensitivity
   (ii) Measurement of CDR
   (iii) Determine a high resistance by Leakage Method
   iv) To determine Self Inductance of a Coil by Rayleigh's Method.
3. To compare capacitances using De'Sauty's bridge.
4. Measurement of field strength B & its variation in a Solenoid (Determine dB/dx).
5. To study the Characteristics of a Series RC Circuit.
6. To study a series LCR circuit and determine its (a) Resonant Frequency, (b) Quality Factor.
7. To study a parallel LCR circuit and determine its (a) Anti-resonant frequency and (b) Quality factor Q.
8. To determine a Low Resistance by Carey Foster's Bridge.
9. To verify the Thevenin and Norton theorem
10. To verify the Superposition, and Maximum Power Transfer Theorem

References for Theory

Essential Readings

1. Vector analysis – Schaum's Outline, M.R. Spiegel, S. Lipschutz, D. Spellman, 2ndEdn., 2009, McGraw- Hill Education.
2. Electricity & Magnetism, J.H. Fewkes & J. Yarwood. Vol. I, 1991, Oxford Univ. Press
3. Electricity and Magnetism, D C Tayal, 1988, Himalaya Publishing House.
4. Fundamentals of Electromagnetics, M.A.W. Miah, 1982, Tata McGraw Hill
5. D.J. Griffiths, Introduction to Electrodynamics, 3rd Edn, 1998, Benjamin Cummings.

Additional Readings

1. Electricity and Magnetism, Edward M. Purcell, 1986, McGraw-Hill Education.
2. University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.

References for Laboratory

1. Advanced Practical Physics for students, B.L.Flint & H.T.Worsnop, 1971, Asia Publishing House.
2. Engineering Practical Physics, S.Panigrahi & B.Mallick,2015, Cengage Learning India Pvt. Ltd.
3. A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Edition, 2011, Kitab Mahal, New Delhi.
4. Practical Physics, G.L. Squires, 2015, 4th Edition, Cambridge University Press

CC-3A: Thermal Physics and Statistical Mechanics (42224303)
Credit: 06 (Theory-04, Practical-02)
Theory: 60 Hours
Practical: 60 Hours

Course Objective

This course will introduce Thermodynamics, Kinetic theory of gases and Statistical Mechanics to the students. The primary goal is to understand the fundamental laws of thermodynamics and its applications to various thermodynamical systems and processes. This coursework will also enable the students to understand the connection between the macroscopic observations of physical systems and microscopic behavior of atoms and molecules through Statistical mechanics.

Course Learning Outcomes

At the end of this course, students will

- Learn the basic concepts of thermodynamics, the first and the second law of thermodynamics, the concept of entropy and the associated theorems, the thermodynamic potentials and their physical interpretations. They are also expected to learn Maxwell's thermodynamic relations.
- Know the fundamentals of the kinetic theory of gases, Maxwell-Boltzman distribution law, equipartition of energies, mean free path of molecular collisions, viscosity, thermal conductivity, diffusion and Brownian motion.
- Learn about the black body radiations, Stefan- Boltzmann's law, Rayleigh-Jean's law and Planck's law and their significances.

- Learn the quantum statistical distributions, viz., the Bose-Einstein statistics and the Fermi-Dirac statistics.
- In the laboratory course, the students are expected to: Measure of Planck’s constant using black body radiation, determine Stefan’s Constant, coefficient of thermal conductivity of a bad conductor and a good conductor, determine the temperature co-efficient of resistance, study variation of thermo emf across two junctions of a thermocouple with temperature etc.

Unit 1

Thermodynamic Description of system: Zeroth Law of thermodynamics and temperature. First law and internal energy, conversion of heat into work, Various Thermodynamical Processes, Applications of First Law: General Relation between Cp and Cv, Work Done during Isothermal and Adiabatic Processes, Compressibility and Expansion Coefficient, Reversible and irreversible processes, Second law, Entropy, Carnot’s cycle & theorem, Entropy changes in reversible and irreversible processes, Entropy-temperature diagrams, Third law of thermodynamics, Unattainability of absolute zero.

(22 lectures)

Unit 2

Thermodynamic Potentials: Enthalpy, Gibbs, Helmholtz and Internal Energy functions, Maxwell’s relations and applications - Joule-Thomson Effect, Clausius Clapeyron Equation, Expression for (Cp – Cv), Cp/Cv, TdS equations.

(10 lectures)

Unit 3

Kinetic Theory of Gases: Derivation of Maxwell’s law of distribution of velocities and its experimental verification, Mean free path (Zeroth Order), Transport Phenomena: Viscosity, Conduction and Diffusion (for vertical case), Law of equipartition of energy (no derivation) and its applications to specific heat of gases; mono-atomic and diatomic gases.

(10 lectures)

Unit 4

Theory of Radiation: Blackbody radiation, Spectral distribution, Derivation of Planck's law, Deduction of Wien’s distribution law, Rayleigh Jeans Law, Stefan Boltzmann Law and Wien’s displacement law from Planck’s law.

(6 lectures)

Unit 5

Statistical Mechanics: Microstate and Microstate, Phase space, Entropy and Thermodynamic probability, Maxwell- Boltzmann law, Quantum statistics, Fermi-Dirac distribution law, Bose-Einstein distribution law, comparison of three statistics.

(12 lectures)

PRACTICAL (60 Hours)
PHYSICS LAB: CC-3A LAB: Thermal Physics and Statistical Mechanics

Sessions on the construction and use of specific measurement instruments and experimental apparatuses used in the thermal physics lab, including necessary precautions.

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. Application to the specific experiments done in the lab.

At least 06 experiments from the following:

1. To determine Mechanical Equivalent of Heat, J, by Callender and Barne's constant flow method.
2. Measurement of Planck's constant using black body radiation.
3. To determine Stefan's Constant.
4. To determine the coefficient of thermal conductivity of Cu by Searle's Apparatus.
5. To determine the coefficient of thermal conductivity of a bad conductor by Lee and Charlton's disc method.
6. To determine the temperature co-efficient of resistance by Platinum resistance thermometer.
7. To study the variation of thermo emf across two junctions of a thermocouple with temperature.

References for Theory

Essential Readings

1. Thermal Physics, S. Garg, R. Bansal and C. Ghosh, 1993, Tata McGraw-Hill.
2. A Treatise on Heat, Meghnad Saha, and B.N. Srivastava, 1969, Indian Press.
3. Heat and Thermodynamics, M.W. Zemasky and R. Dittman, 1981, McGraw Hill
4. Thermodynamics, Kinetic theory & Statistical thermodynamics, F.W.Sears and G.L.Salinger. 1988, Narosa Publications
5. Statistical Physics, Franz Mandl, 1988, 2nd Edition. Wiley.

Additional Readings

1. University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.
2. Thermal Physics and Statistical Mechanics, A. Kumar and S.P. Taneja, 2015, R. Chand & Co. Publications.
3. Practical Physics, G.L. Squires, 2015, 4th Edition, Cambridge University Press
4. B.Sc. Practical Physics, H. Singh & P. S. Hemne, 2011, S Chand and Company Ltd
5. B.Sc. Practical Physics, C. L. Arora, 2011, S Chand and Company Ltd.

Reference for Laboratory work

1. Advanced Practical Physics for students, B.L. Flint & H.T. Worsnop, 1971, Asia Publishing House.
2. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
3. A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Edition, 2011, Kitab Mahal, New Delhi.
4. A Laboratory Manual of Physics for Undergraduate Classes, D. P. Khandelwal,1985, Vani Publication.
5. An Advanced Course in Practical Physics, D. Chattopadhyay & P. C. Rakshit, 2013, New Book Agency (P) Ltd.

CC-4A: Waves and Optics (42224412)
Credit: 06 (Theory-04, Practical-02)
Theory: 60 Hours
Practical: 60 Hours

Course Objective

This course reviews the concepts of waves and optics learnt at school from a more advanced perspective and goes on to build new concepts. It begins with explaining ideas of superposition of harmonic oscillations leading to physics of travelling and standing waves. The course also provides an in depth understanding of wave phenomena of light, namely, interference and diffraction with emphasis on practical applications of the same.

Course Learning Outcomes

On successfully completing the requirements of this course, the students will have the skill and knowledge to:

- Understand Simple harmonic oscillation and superposition principle.
- Understand the importance of classical wave equation in transverse and longitudinal waves and solving a range of physical systems on its basis.
- Understand Concept of normal modes in transverse and longitudinal waves: their frequencies and configurations.
- Understand Interference as superposition of waves from coherent sources derived from same parent source. Demonstrate understanding of Interference experiments: Young's Double Slit, Fresnel's biprism, Llyod's Mirror, Newton's Rings.
- Demonstrate basic concepts of Diffraction: Superposition of wavelets diffracted from apertures. Understand Fraunhoffer Diffraction from a slit.

- Concept of Polarization
- In the laboratory course, student will gain hands-on experience of using various optical instruments and making finer measurements of wavelength of light using Newton Rings experiment, Fresnel Biprism etc. Resolving power of optical equipment can be learnt first hand.
- The motion of coupled oscillators, study of Lissajous figures and behaviour of transverse, longitudinal waves can be learnt in this laboratory course.

Unit 1

Superposition of Two Collinear Harmonic oscillations: Simple harmonic motion (SHM). Linearity and Superposition Principle. (1) Oscillations having equal frequencies and (2) Oscillations having different frequencies (Beats).

(6 Lectures)

Superposition of Two Perpendicular Harmonic Oscillations: Graphical and Analytical Methods. Lissajous Figures (1:1 and 1:2) and their uses.

(2 Lectures)

Waves Motion- General: Transverse waves on a string. Travelling and standing waves on a string. Normal Modes of a string. Group velocity, Phase velocity. Plane waves. Spherical waves, Wave intensity.

(8 Lectures)

Unit 2

Sound: Sound waves, production and properties. Intensity and loudness of sound. Decibels. Intensity levels. musical notes. musical scale. Acoustics of buildings (General idea).

(6 Lectures)

Wave Optics: Electromagnetic nature of light. Definition and Properties of wave front. Huygens Principle.

(**3 Lectures)**

Unit 3

I**nterference:** Division of amplitude and division of wave front. Young's Double Slit experiment. Lloyd's Mirror & Fresnel's Biprism. Phase change on reflection: Stokes' treatment. Interference in Thin Films: parallel and wedge-shaped films. Fringes of equal inclination (Haidinger Fringes); Fringes of equal thickness (Fizeau Fringes). Newton's Rings: measurement of wavelength and refractive index.

(12 Lectures)

Michelson's Interferometer: Construction and working. Idea of form of fringes (no theory needed), Determination of wavelength, Wavelength difference, Refractive index, and Visibility of fringes.

(4 Lectures)

Unit 4

Diffraction: Fraunhofer diffraction: Single slit; Double Slit. Multiple slits & 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.

(14 Lectures)

Polarization: Transverse nature of light waves. Plane polarized light – production and analysis. Circular and elliptical polarization (General Idea).

(5 Lectures)

PRACTICAL (60 Hours)
PHYSICS LAB: CC- 4A LAB: Waves and Optics

Dedicated demonstration cum laboratory session on the construction, and use of spectrometer and lasers, and necessary precautions during their use.

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.
Application to the specific experiments done in the lab.

At least 08 experiments from the following:

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 focusing; determination of angle of prism.
5. To determine the Refractive Index of the Material of given Prism using Na Light.
6. To determine Dispersive Power of the Material of a given Prism using Hg Light.
7. To determine the value of Cauchy Constants of a material of a prism.
8. To determine the Resolving Power of a Prism.
9. To determine wavelength of sodium light using Fresnel Biprism.
10. To determine wavelength of sodium light using Newton's Rings.
11. To determine the wavelength of Laser light using diffraction of single slit.
12. To determine wavelength of (1) Sodium and (2) Mercury light using plane diffraction Grating.
13. To determine the Resolving Power of a Plane Diffraction Grating.
14. To determine the wavelength of Laser light using Diffraction grating.

References for Theory:

Essential Reading

1. Waves and Optics, S.P.Taneja, R.Chand and Pub., New Delhi, 2017.
2. The Physics of Waves and Oscillations, N.K. Bajaj, 1998, Tata McGraw Hill.
3. Optics, (2017), 6th Edition, Ajoy Ghatak, McGraw-Hill Education, New Delhi
4. Fundamentals of Optics, A. Kumar, H.R. Gulati and D.R. Khanna, 2011, R. Chand Publications.

5. University Physics. F.W. Sears, M.W. Zemansky and H.D. Young. 13/e, 1986. Addison-Wesley.

Additional Readings

1. Vibrations and Waves, A.P. French, 1st Edn., 2003, CRC press.
2. Principles of Optics, B.K. Mathur, 1995, Gopal Printing
3. Fundamentals of Optics, F.A Jenkins and H.E White, 1976, McGraw-Hill
4. B.Sc. Practical Physics, H. Singh & P. S. Hemne, 2011, S Chand and Company Ltd
5. B.Sc. Practical Physics, C. L. Arora, 2011, S Chand and Company Ltd.
6. Engineering Practical Physics, S.Panigrahi & B.Mallick,2015, Cengage Learning India Pvt. Ltd.

Reference for Laboratory work

1. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
2. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
3. A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Edition, 2011, Kitab Mahal, New Delhi.
4. An Advanced Course in Practical Physics, D. Chattopadhyay & P. C. Rakshit, 2013, New Book Agency (P) Ltd.
5. Practical Physics, G.L. Squires, 2015, 4th Edition, Cambridge University Press

9.2. Skill-Enhancement Elective Course - (SEC)
Students should not take the same SEC paper in different Semesters

SEC: Physics Workshop Skills (32223901)
Credit:04 (Theory-02, Practical-02)
Theory: 30 Hours
Practical: 60 Hours

Course Objective

The aim of this course is to enable the students to be familiar and have experience of various mechanical and electrical tools through hands-on mode. This course enables students to understand working of various measuring devices and different type of errors encountered in the measurement process. This course also develops the mechanical skills of the students by direct exposure to different machines and tools by demonstration and experimental technique.

Course Learning Outcomes

After completing this course, student will be able to:

- Use measuring devices like Vernier calipers, Screw gauge, travelling microscope and Sextant for measuring various length scales.
- Acquire skills in the usage of multimeter, soldering iron, oscilloscopes, power supplies and relays.
- Develop mechanical skills such as casting, foundry, machining, forming and welding and will become familiar with common machine tools like lathe, shaper, drill, milling machine, surface machines and cutting tools.
- Get acquainted with prime movers: mechanism, gear system, wheel, fixing of gears with motor axle, lever mechanism, lifting of heavy weight using lever, braking systems, pulleys.

Unit 1

Introduction: Measuring devices: Vernier calliper, Screw gauge and travelling microscope. Measure the dimension of a solid block, volume of cylindrical beaker/glass, diameter of a thin wire, thickness of metal sheet, etc. Use of Sextant to measure height of buildings, mountains, etc.

(6 lectures)

Unit 2

Mechanical Skill: Overview of manufacturing methods: casting, foundry, machining, forming and welding. Types of welding joints and welding defects. Concept of machine processing, introduction to common machine tools like lathe, shaper, drilling, milling and surface machines. Cutting tools, lubricating oils. Cutting of a metal sheet using blade. Smoothening of cutting edge of sheet using file. Drilling of holes of different diameter in metal sheet and wooden block. Use of bench vice and tools for fitting. Make funnel using metal sheet.

(14 Lectures)

Unit 3

Introduction to prime movers: Mechanism, gear system, wheel, Fixing of gears with motor axel. Lever mechanism, Lifting of heavy weight using lever. braking systems, pulleys, working principle of power generation systems. Demonstration of pulley experiment.

(10 Lectures)

Practical: (60 Hours)
PRACTICALS SEC LAB: Physics Workshop Skills

Sessions on the use of equipment used in the workshop, including necessary precautions.

Sessions on the review of experimental data analysis, error analysis and reporting and their application to the specific experiments done in the lab.

Main emphasis is on taking observations, calculations, graph and result. Perform at least three practicals from the following.

Teacher may give long duration project based on this paper.
All experiments are compulsory.

1. Comparison of diameter of a thin wire using screw gauge and travelling microscope.
2. Drilling of Hole in metal, wood and plastic.
3. Cutting of metal sheet.
4. Cutting of glass sheet
5. Lifting of heavy weights using simple pulley/lever arrangement.

References

1. A text book in Electrical Technology, B. L. Theraja, S. Chand and Company.·
2. Performance and design of AC machines – M.G. Say, ELBS Edn.
3. Performance and design of AC machines, M. G. Say, ELBS Edn.
4. Mechanical workshop practice, K.C. John, 2010, PHI Learning Pvt. Ltd.
5. Workshop Processes, Practices and Materials, Bruce J Black 2005, 3rd Edn., Editor Newnes [ISBN: 0750660732] New Engineering Technology, Lawrence Smyth/Liam Hennessy, The Educational Company of Ireland [ISBN0861674480].

SEC: Computational Physics Skills (32223902)
Credit:04 (Theory-02, Practical-02)
Theory: 30 Hours
Practical: 60 Hours

Course Objectives

This course is intended to give an insight into computers and their scientific applications. To familiarize students with the use of computer to solve physics problems. To teach a programming language namely FORTRAN and data visualization using Gnuplot. To teach them to prepare long formatted document using latex.

Course Learning Outcomes

Students will be able to

- Use computers for solving problems in Physics.
- Prepare algorithms and flowcharts for solving a problem.
- Use Linux commands on terminal
- Use an unformatted editor to write sources codes.
- Learn "Scientific Word Processing", in particular, using LaTeX for preparing articles, papers etc. which include mathematical equations, picture and tables.
- Learn the basic commands of Gnuplot.

Unit 1

Introduction : Importance of computers in Physics, paradigm for solving physics problems. Usage of editor in Linux.

Algorithms and Flowcharts: Algorithm: Definition, properties and development. Flowchart: Concept of flowchart, symbols, guidelines, types. Examples: Cartesian to Spherical Polar Coordinates, Roots of Quadratic Equation, Sum of two matrices, Sum and Product of a finite series, calculation of sin(x) as a series, algorithm for plotting (1) Lissajous figures and (2) trajectory of a projectile thrown at an angle with the horizontal.

(4 Lectures)

Scientific Programming: Some fundamental Linux Commands (Internal and External commands). Development of FORTRAN, Basic elements of FORTRAN: Character Set, Constants and their types, Variables and their types, Keywords, Variable Declaration and concept of instruction and program. Operators: Arithmetic, Relational, Logical and Assignment Operators. Expressions: Arithmetic, Relational, Logical, Character and Assignment Expressions. Fortran Statements: I/O Statements (unformatted/formatted), Executable and Non-Executable Statements, Layout of Fortran Program, Format of writing Program and concept of coding, Initialization and Replacement Logic. Examples from physics problems.

(5 Lectures)

Unit 2

Control Statements: Types of Logic(Sequential, Selection, Repetition), Branching Statements (Logical IF, Arithmetic IF, Block IF, Nested Block IF, SELECT CASE and ELSE IF Ladder statements), Looping Statements (DO- CONTINUE, DO-ENDDO, DO-WHILE, Implied and Nested DO Loops), Jumping Statements (Unconditional GOTO, Computed GOTO, Assigned GOTO) Subscripted Variables (Arrays: Types of Arrays, DIMENSION Statement, Reading and Writing Arrays), Functions and Subroutines (Arithmetic Statement Function, Function Subprogram and Subroutine), RETURN, CALL, COMMON and EQUIVALENCE Statements), Structure, Disk I/O Statements, open a file, writing in a file, reading from a file. Examples from physics problems.

Programming:

1. Exercises on syntax on usage of FORTRAN
2. Usage of GUI Windows, Linux Commands, familiarity with DOS commands and working in an editor to write sources codes in FORTRAN.
3. To print out all natural even/ odd numbers between given limits.
4. To find maximum, minimum and range of a given set of numbers.
5. Calculating Euler number using exp(x) series evaluated at x=1

(6 Lectures)

Unit 3

Scientific word processing: Introduction to LaTeX: TeX/LaTeX word processor, preparing a basic LaTeX file, Document classes, Preparing an input file for LaTeX, Compiling LaTeX File, LaTeX tags for creating different environments, Defining LaTeX commands and environments, Changing the type style, Symbols from other languages. Equation representation: Formulae and equations, Figures and other floating bodies, Lining in columns- Tabbing and tabular environment, Generating table of contents, bibliography and citation, Making an index and glossary, List making environments, Fonts, Picture environment and colors, errors.

(6 Lectures)

Unit 4

Visualization: Introduction to graphical analysis and its limitations. Introduction to Gnuplot. importance of visualization of computational and computational data, basic Gnuplot commands: simple plots, plotting data from a file, saving and exporting, multiple data sets per file, physics with Gnuplot (equations, building functions, user defined variables and functions), Understanding data with Gnuplot

(9 Lectures)

Practicals/Hands on exercises: (60 Hours)
PRACTICALS SEC LAB: Computational Physics Skills

"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. Application to the specific experiments done in the lab."

Teacher may give long duration project based on this paper.

Hands on exercises: (Use of latest Fortran compiler is advisable.)

Students are advised to finish all exercises.

1. To compile a frequency distribution and evaluate mean, standard deviation etc.
2. To evaluate sum of finite series and the area under a curve.
3. To find the product of two matrices
4. To find a set of prime numbers and Fibonacci series.
5. To write program to open a file and generate data for plotting using Gnuplot.
6. Plotting trajectory of a projectile projected horizontally.
7. Plotting trajectory of a projectile projected making an angle with the horizontally.
8. Creating an input Gnuplot file for plotting a data and saving the output for seeing on the screen. Saving it as an eps file and as a pdf file.
9. To find the roots of a quadratic equation.
10. Motion of a projectile using simulation and plot the output for visualization.
11. Numerical solution of equation of motion of simple harmonic oscillator and plot the outputs for visualization.
12. Motion of particle in a central force field and plot the output for visualization.

References

Essential Readings

1. Introduction to Numerical Analysis, S.S. Sastry, 5th Edn., 2012, PHI Learning Pvt. Ltd.
2. LaTeX–A Document Preparation System, Leslie Lamport (Second Edition, Addison-Wesley, 1994).
3. Gnuplot in action: understanding data with graphs, Philip K Janert, (Manning 2010)
4. Schaum's Outline of Theory and Problems of Programming with Fortran, S Lipsdutz and A Poe, 1986 Mc-Graw Hill Book Co.
5. Computational Physics: An Introduction, R. C. Verma, et al. New Age International Publishers, New Delhi (1999)
6. Elementary Numerical Analysis, K. E. Atkinson, 3rd Edn., 2007, Wiley India Edition.

Additional Readings

1. Computer Programming in Fortran 77. V. Rajaraman (Publisher:PHI).
2. Computational Physics - A practical Introduction to computational Physics and Scientific Computing; by Konstantinos N. Anagnostopoulos

SEC: Electrical circuits and Network Skills (32223903)
Credit:04 (Theory-02, Practical-02)
Theory: 30 Hours
Practical: 60 Hours

Course Objective

To develop an understanding of basic principles of electricity and its household applications. To impart basic knowledge of solid state devices and their applications, understanding of electrical wiring and installation.

Course Learning Outcomes

At the end of this course, students will be able to

- Demonstrate good comprehension of basic principles of electricity including ideas about voltage, current and resistance.
- Develop the capacity to analyze and evaluate schematics of power efficient electrical circuits while demonstrating insight into tracking of interconnections within elements while identifying current flow and voltage drop.
- Gain knowledge about generators, transformers and electric motors. The knowledge would include interfacing aspects and consumer defined control of speed and power.
- Acquire capacity to work theoretically and practically with solid-state devices.
- Delve into practical aspects related to electrical wiring like various types of conductors and cables, wiring-Star and delta connections, voltage drop and losses.
- Measure current, voltage, power in DC and AC circuits, acquire proficiency in fabrication of regulated power supply.
- Develop capacity to identify and suggest types and sizes of solid and stranded cables, conduit lengths, cable trays, splices, crimps, terminal blocks and solder.

Unit 1

Basic Electricity Principles: Voltage, Current, Resistance, and Power. Ohm's law. Series, parallel, and series-parallel combinations. AC and DC Electricity. Familiarization with multimeter, voltmeter and ammeter.

(3 Lectures)

Electrical Circuits: Basic electric circuit elements and their combination. Rules to analyze DC sourced electrical circuits. Current and voltage drop across the DC circuit elements. Single-phase and three-phase alternating current sources. Rules to analyze AC sourced electrical circuits. Real, imaginary and complex power components of AC source. Power factor. Saving energy and money.

(4 Lectures)

Electrical Drawing and Symbols: Drawing symbols. Blueprints. Reading Schematics. Ladder diagrams. Electrical Schematics. Power circuits. Control circuits. Reading of circuit schematics. Tracking the connections of elements and identify current flow and voltage drop.

(4 Lectures)

Generators and Transformers: DC Power sources. AC/DC generators. Inductance, capacitance, and impedance. Operation of transformers.

(2 Lectures)

Electric Motors: Single-phase, three-phase & DC motors. Basic design. Interfacing DC or AC sources to control heaters and motors. Speed & power of ac motor.

(3 Lectures)

Unit 2

Solid-State Devices: Resistors, inductors and capacitors. Diode and rectifiers. Components in Series or in shunt. Response of inductors and capacitors with DC or AC sources.

(3 Lectures)

Electrical Protection: Relays. Fuses and disconnect switches. Circuit breakers. Overload devices. Ground-fault protection. Grounding and isolating. Phase reversal. Surge protection. Relay protection device.

(3 Lectures)

Electrical Wiring: Different types of conductors and cables. Basics of wiring-Star and delta connection. Voltage drop and losses across cables and conductors. Instruments to measure current, voltage, power in DC and AC circuits. Insulation. Solid and stranded cable. Conduit. Cable trays. Splices: wirenuts, crimps, terminal blocks, and solder. Preparation of extension board.

(5 Lectures)

Network Theorems: (1) Thevenin theorem (2) Norton theorem (3) Superposition theorem (4) Maximum Power Transfer theorem.

(3 Lectures)

Practical: (60 Hours)
PRACTICALS SEC LAB: Electric Circuit and Network Skills

Sessions on the construction and use of specific measurement instruments and experimental apparatuses used in the physics lab, including necessary precautions.

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. Application to the specific experiments done in the lab.

Teacher may give long duration project based on this paper.

At least 08 Experiments from the following

1. Series and Parallel combinations: Verification of Kirchoff's law.
2. To verify network theorems: (I) Thevenin (II) Norton (III) Superposition theorem (IV) Maximum power transfer theorem
3. To study frequency response curve of a Series LCR circuit.
4. To verify (1) Faraday's law and (2) Lenz's law.
5. Programming with Pspice/NG spice.
6. Demonstration of AC and DC generator.
7. Speed of motor
8. To study the characteristics of a diode.
9. To study rectifiers (I) Half wave (II) Full wave rectifier (III) Bridge rectifier
10. Power supply (I) C-filter, (II) π- filter
11. Transformer – Step up and Step down
12. Preparation of extension board with MCB/fuse, switch, socket-plug, Indicator.
13. Fabrication of Regulated power supply.

It is further suggested that students may be motivated to pursue semester long dissertation wherein he/she may do a hands-on extensive project based on the extension of the practicals enumerated above.

References for Theory

Essential Readings

1. Electrical Circuits, K.A. Smith and R.E. Alley, 2014, Cambridge University Press
2. Performance and design of AC machines - M G Say ELBS Edn.
3. Electronic Devices and Circuits, A Mothershead, 1998, PHI Learning Pvt. Ltd.
4. Network, Lines and Files, John D. Ryder, V Perarson 2nd Edn.,2015.

References for Laboratory

1. A text book in Electrical Technology - B L Theraja - S Chand & Co.

2. Electrical Circuit Analysis, K. Mahadevan and C. Chitran, 2nd Edition, 2018, PHI learning Pvt. Ltd.

SEC: Basic Instrumentation Skills (32223904)
Credit:04 (Theory-02, Practical-02)
Theory: 30 Hours
Practical: 60 Hours

Course Objective

To expose the students to various aspects of instruments and their usage through hands-on mode. To provide them a thorough understanding of basics of measurement, measurement devices such as electronic voltmeter, Oscilloscope, signal and pulse generators, Impedance bridges, digital instruments etc.

Course Learning Outcomes

At the end of this course the students will learn the following:

- The student is expected to have the necessary working knowledge on accuracy, precision, resolution, range and errors/uncertainty in measurements.
- Course learning begins with the basic understanding of the measurement and errors in measurement. It then familiarizes about each and every specification of a multimeter, multimeters, multivibrators, rectifiers, amplifiers, oscillators and high voltage probes and their significance with hands on mode.
- Explanation of the specifications of CRO and their significance. Complete explanation of CRT.
- Students learn the use of CRO for the measurement of voltage (DC and AC), frequency and time period. Covers the Digital Storage Oscilloscope and its principle of working.
- Students learn principles of voltage measurement. Students should be able to understand the advantages of electronic voltmeter over conventional multimeter in terms of sensitivity etc. Types of AC millivoltmeter should be covered.
- Covers the explanation and specifications of Signal and pulse Generators: low frequency signal generator and pulse generator. Students should be familiarized with testing and specifications.
- Students learn about the working principles and specifications of basic LCR bridge.
- Hands on ability to use analog and digital instruments like digital multimeter and frequency counter.

Unit 1

Basic of Measurement: Instruments accuracy, precision, sensitivity, resolution range etc. Errors in measurements and loading effects. Multimeter: Principles of measurement of dc voltage and dc current, ac voltage, ac current and resistance. Specifications of a multimeter and their significance.

(4 Lectures)

Electronic Voltmeter: Advantage over conventional multimeter for voltage measurement with respect to input impedance and sensitivity. Principles of voltage, measurement (block diagram only). Specifications of an electronic Voltmeter/ Multimeter and their significance.AC millivoltmeter: Type of AC millivoltmeters. Block diagram ac millivoltmeter, specifications and their significance.

(4 Lectures)

Unit 2

Oscilloscope: Block diagram of basic CRO. CRT, electrostatic focusing and acceleration (Explanation only– no mathematical treatment), brief discussion on screen phosphor, visual persistence. Time base operation, synchronization. Front panel controls. Specifications of CRO and their significance.

(6 Lectures)

Use of CRO: for the measurement of voltage (dc and ac), frequency and time period. Special features of dual trace, introduction to digital oscilloscope, probes. Digital storage Oscilloscope: principle of working.

(3 Lectures)

Unit 3

Signal and pulse Generators: Block diagram, explanation and specifications of low frequency signal generator and pulse generator. Brief idea for testing, specifications.Distortion factor meter, wave analysis.

(4 Lectures)

Impedance Bridges: Block diagram of bridge. Working principles of basic (balancing type) RLC bridge. Specifications of RLC bridge. Block diagram and working principles of a Q- Meter. Digital LCR bridges.

(3 Lectures)

Unit 4

Digital Instruments: Comparison of analog & digital instruments. Characteristics of a digital meter. Working principles of digital voltmeter.

(3 Lectures)

Digital Multimeter: Block diagram and working of a digital multimeter. Working principle of time interval, frequency and period measurement using universal counter/ frequency counter, time- base stability, accuracy and resolution.

(3 Lectures)

Practical : (60 Hours)
PRACTICALS SEC LAB: Basic Instrumentation Skills

Session on the construction and use of CRO, and other experimental apparatuses used in the lab, including necessary precautions.

Sessions on the review of experimental data analysis, error analysis and reporting and their application to the specific experiments done in the lab.
The test of lab skills will be of the following test items:

1. Use of an oscilloscope.
2. Oscilloscope as a versatile measuring device.
3. Circuit tracing of Laboratory electronic equipment,
4. Use of Digital multimeter /VTVM for measuring voltages
5. Circuit tracing of Laboratory electronic equipment,
6. Winding a coil / transformer.
7. Study the layout of receiver circuit.
8. Trouble shooting a circuit
9. Balancing of bridges

Teacher may give long duration project based on this paper.

Practicals:

1. To observe the loading effect of a multimeter while measuring voltage across a low resistance and high resistance.
2. To observe the limitations of a multimeter for measuring high frequency voltage and currents.
3. To measure Q of a coil and its dependence on frequency, using a Q- meter.
4. Measurement of voltage, frequency, time period and phase using Oscilloscope.
5. Measurement of time period, frequency, average period using universal counter/ frequency counter.
6. Measurement of rise, fall and delay times using a Oscilloscope.
7. Measurement of distortion of a RF signal generator using distortion factor meter.
8. Measurement of R,L and C using a LCR bridge/ universal bridge.

Open Ended Experiments:

1. Using a Dual Trace Oscilloscope
2. Converting the range of a given measuring instrument (voltmeter, ammeter).

It is further suggested that students may be motivated to pursue semester long dissertation wherein he/she may do a hands-on extensive project based on the extension of the practicals enumerated above.

References for Theory

Essential Readings

1. Digital Circuits and systems, Venugopal, 2011, Tata McGraw Hill.
2. Logic circuit design, Shimon P. Vingron, 2012, Springer.
3. Digital Electronics, Subrata Ghoshal, 2012, Cengage Learning.
4. Electronic Instrumentation, H.S. Kalsi, 3rd Ed., McGraw Hill Education.

Additional Readings

1. Performance and design of AC machines - M G Say ELBS Edn.

References for Laboratory

1. A text book in Electrical Technology - B L Theraja - S Chand and Co.
2. Electronic Devices and circuits, S. Salivahanan & N. S.Kumar, 3rd Ed., 2012, Tata Mc-Graw Hill.

SEC: Renewable Energy and Energy harvesting (32223905)
Credit:04 (Theory-02, Practical-02)
Theory: 30 Hours
Practical: 60 Hours

Course Objective

To impart knowledge and hands on learning about various alternate energy sources to teach the ways of harvesting energy using wind, solar, mechanical, ocean, geothermal energy etc. To review the working of various energy harvesting systems which are installed worldwide.

Course Learning Outcomes

At the end of this course, students will be able to achieve the following learning outcomes:

- Knowledge of various sources of energy for harvesting
- Understand the need of energy conversion and the various methods of energy storage
- A good understanding of various renewable energy systems, and its components.
- Knowledge about renewable energy technologies, different storage technologies, distribution grid, smart grid including sensors, regulation and their control.
- Design the model for sending the wind energy or solar energy plant.
- The students will gain hand on experience of:
    - (i) different kinds of alternative energy sources,
    - (ii) conversion of vibration into voltage using piezoelectric materials,
    - (iii) conversion of thermal energy into voltage using thermoelectric modules.

Unit 1

Fossil fuels and Alternate Sources of energy: Fossil fuels and nuclear energy, their limitation, need of renewable energy, non-conventional energy sources. An overview of developments in Offshore Wind Energy, Tidal Energy, Wave energy systems, Ocean Thermal Energy Conversion, solar energy, biomass, biochemical conversion, bio-gas generation, geothermal energy tidal energy, Hydroelectricity.

(3 Lectures)

Unit 2

Solar energy: Solar energy, its importance, storage of solar energy, solar pond, non--convective solar pond, applications of solar pond and solar energy, solar water heater, flat plate collector, solar distillation, solar cooker, solar green houses, solar cell, absorption air conditioning. Need and characteristics of photo-voltaic (PV) systems, PV models and equivalent circuits, and sun tracking systems.

(6 Lectures)

Unit 3

Wind Energy harvesting: Fundamentals of Wind energy, Wind Turbines and different electrical machines in wind turbines, Power electronic interfaces, and grid interconnection topologies.

(3 Lectures)

Unit 4

Ocean Energy: Ocean Energy Potential against Wind and Solar, Wave Characteristics and Statistics, Wave Energy Devices.
Tide characteristics and Statistics, Tide Energy Technologies, Ocean Thermal Energy, Osmotic Power, Ocean Bio-mass.
Geothermal Energy: Geothermal Resources, Geothermal Technologies.
Hydro Energy: Hydropower resources, hydropower technologies, environmental impact of hydro power sources. Rain water harvesting.

(9 Lectures)

Unit 5

Piezoelectric Energy harvesting: Introduction, Physics and characteristics of piezoelectric effect, materials and mathematical description of piezo-electricity, Piezoelectric parameters and modeling piezoelectric generators, Piezoelectric energy harvesting applications, Human power
Electromagnetic Energy Harvesting: Linear generators, physical/mathematical models, recent applications Carbon captured technologies, cell, batteries, power consumption Environmental issues and Renewable sources of energy, sustainability. Merits of Rain Water harvesting

(9 Lectures)

Practical : (60 Hours)
PRACTICALS SEC LAB: Renewable Energy and Energy Harvesting

Sessions on the use of equipment used in the workshop, including necessary precautions.

Sessions on the review of experimental data analysis, error analysis and reporting and their application to the specific experiments done in the lab.

Teacher may give long duration project based on this paper.

Demonstrations and Experiments:

1. Demonstration of Training modules on Solar energy, wind energy, etc.
2. Conversion of vibration to voltage using piezoelectric materials
3. Conversion of thermal energy into voltage-driven thermo-electric modules.

References for Theory

Essential Readings

1. Solar energy, Suhas P Sukhative, Tata McGraw - Hill Publishing Company Ltd.
2. Renewable Energy, Power for a sustainable future, Godfrey Boyle, 3rd Edn., 2012, Oxford University Press.

Additional Readings

1. Solar Energy: Resource Assessment Handbook, P Jayakumar, 2009
2. J. Balfour, M. Shaw and S. Jarosek, Photo-voltaics, Lawrence J Goodrich (USA).
3. http://en.wikipedia.org/wiki/Renewable_energy

References for Laboratory

1. Non-conventional energy sources, B.H. Khan, McGraw Hill 60

SEC: Engineering Design and Prototyping/Technical Drawing (32223906)
Credit:04 (Theory-02, Practical-02)
Theory: 30 Hours
Practical: 60 Hours

Course Objective

To introduce the students to modern visualization techniques and their applications in diverse areas including computer aided design. To offer hands-on experience of engineering drawing based on knowledge gained using computer aided designing software.

Course Learning Outcomes

This course will enable the student to be proficient in:

- Understanding the concept of a sectional view – visualizing a space after being cut by a plane. How The student will be able to draw and learn proper techniques for drawing an aligned section.
- Understanding the use of spatial visualization by constructing an orthographic multi view drawing.
- Drawing simple curves like ellipse, cycloid and spiral, Orthographic projections of points, lines and of solids like cylinders, cones, prisms and pyramids etc.
- Using Computer Aided Design (CAD) software and AutoCAD techniques.

Unit 1

Introduction: Fundamentals of Engineering design, design process and sketching: Scales and dimensioning, Designing to Standards (ISO Norm Elements/ISI), Engineering Curves: Parabola, hyperbola, ellipse and spiral.

(4 Lectures)

Unit 2

Projections: Principles of projections, Orthographic projections: straight lines, planes and solids. Development of surfaces of right and oblique solids. Section of solids. Intersection and Interpenetration of solids. Isometric and Oblique parallel projections of solids.

(10 Lectures)

Unit 3

CAD Drawing: Introduction to CAD and Auto CAD, precision drawing and drawing aids, Geometric shapes, Demonstrating CAD specific skills (graphical user interface, create, retrieve, edit, and use symbol libraries). Use of Inquiry commands to extract drawing data. Control entity properties. Demonstrating basic skills to produce 2-D drawings. Annotating in Auto CAD with text and hatching, layers, templates and design centre, advanced plotting (layouts, viewports), office standards, dimensioning, internet and collaboration, Blocks, Drafting symbols, attributes, extracting data. Basic printing and editing tools, plot/print drawing to appropriate scale.

(10 Lectures)

Unit 4

Computer Aided Design and Prototyping: 3D modeling with AutoCAD (surfaces and solids), 3D modeling with Sketchup, 3D designs, Assembly: Model Editing; Lattice and surface optimization; 2D and 3D packing algorithms, Additive Manufacturing Ready Model Creation (3D printing), Technical drafting and Documentation.

(6 Lectures)

Practicals : (60 Hours)
PRACTICALS SEC LAB: Engineering Design and Prototyping/Technical Drawing

Teacher may give long duration project based on this paper.

Five experiments based on the above theory.

Teacher may design at least five experiments based on the above syllabus.

References for Theory

Essential Readings

1. Engineering Graphic, K. Venugopal and V. Raja Prabhu, New Age International
2. Engineering Drawing, N.S. Parthasarathy and Vele Murali, Ist Edition, 2015, Oxford University Press
3. Don S. Lemons, Drawing Physics, MIT Press, M A Boston, 2018, ISBN:9780262535199
4. AutoCAD 2014 and AutoCAD 2014/Donnie Gladfelter/Sybex/ISBN:978-1-118-57510-9
5. Architectural Design with Sketchup/Alexander Schreyer/John Wiley & Sons/ISBN:978-1-118-12309-6.

Additional Readings

1. Engineering Drawing, Dhananjay A Jolhe, McGraw-Hill
2. James A. Leach, AutoCAD 2017 Instructor, SDC publication, Mission, KS 2016. ISBN: 978163057029.
3. Analysis of Mechanisms and Machines, M A Boston, McGraw-Hill, 2007.

SEC : Radiation Safety (32223907)
Credit:04 (Theory-02, Practical-02)
Theory: 30 Hours
Practical: 60 Hours

Course Objective

This course focusses on the applications of nuclear techniques and radiation protection.
It will not only enhance the skills towards the basic understanding of the radiation but will also provide the knowledge about the protective measures against the radiation exposure.
It imparts all the skills required by a radiation safety officer or any job dealing with radiation such as X-ray operators, nuclear medicine dealing jobs: chemotherapists, PET MRI CT scan, gamma camera etc. operators etc.

Course Learning Outcomes

This course will help students in the following ways:

- Awareness and understanding the hazards of radiation and the safety measures to guard against these hazards.
- Learning the basic aspects of the atomic and nuclear Physics, specially the radiations that originate from the atom and the nucleus.
- Having a comprehensive knowledge about the nature of interaction of matter with radiations like gamma, beta, alpha rays, neutrons etc. and radiation shielding by appropriate materials.
- Knowing about the units of radiations and their safety limits, the devises to detect and measure radiation.
- Learning radiation safety management, biological effects of ionizing radiation, operational limits and basics of radiation hazards evaluation and control, radiation protection standards, 'International Commission on Radiological Protection' (ICRP) its principles, justification, optimization, limitation, introduction of safety and risk management of radiation. nuclear waste and disposal management, brief idea about 'Accelerator driven Sub-Critical System' (ADS) for waste management.
- Learning about the devices which apply radiations in medical sciences, such as MRI, PET.
- Understanding and performing experiments like Study the background radiation levels using Radiation detectors, Determination of gamma ray linear and mass absorption coefficient of a given material for radiation shielding application.

Unit 1

Basics of Atomic and Nuclear Physics: Basic concept of atomic structure; X rays characteristic and production; concept of bremsstrahlung and auger electron, The composition of nucleus and its properties, mass number, isotopes of element, spin, binding energy, stable and unstable isotopes, law of radioactive decay, Mean life and half-life, basic concept of alpha, beta and gamma decay, concept of cross section and kinematics of nuclear reactions, types of nuclear reaction, Fusion, fission.

(6 Lectures)

Unit 2

Interaction of Radiation with matter: Types of Radiation: Alpha, Beta, Gamma and Neutron and their sources, sealed and unsealed sources, Interaction of Photons - Photo-electric effect, Compton Scattering, Pair Production, Linear and Mass Attenuation Coefficients, Interaction of Charged Particles: Heavy charged particles - Beth-Bloch Formula, Scaling laws, Mass Stopping Power, Range, Straggling, Channelling and Cherenkov radiation. Beta Particles- Collision and Radiation loss (Bremsstrahlung), Interaction of Neutrons- Collision, slowing down and Moderation.

(7 Lectures)

Unit 3

Radiation detection and monitoring devices: Radiation Quantities and Units: Basic idea of different units of activity, KERMA, exposure, absorbed dose equivalent dose, effective dose, collective equivalent dose, Annual Limit of Intake (ALI) and derived Air Concentration (DAC). Radiation detection: Basic concept and working principle of gas detectors (Ionization Chambers, Proportional Counter, Multi-Wire Proportional Counters (MWPC) and Geiger Muller Counter), Scintillation Detectors (Inorganic and Organic Scintillators), Solid States Detectors and Neutron Detectors, Thermo luminescent Dosimetry.

Radiation detection: Basic concept and working principle of gas detectors (Ionization Chambers, Proportional Counter and Geiger Muller Counter), Scintillation Detectors (Inorganic and Organic Scintillators), Solid States Detectors and Neutron Detectors, Thermoluminescent Dosimetry.

(7 Lectures)

Unit 4

Radiation safety management: Biological effects of ionizing radiation, Operational limits and basics of radiation hazards evaluation and control: radiation protection standards, International Commission on Radiological Protection (ICRP) principles, justification, optimization, limitations, introduction of safety and risk management of radiation. Nuclear waste and disposal management. Brief idea about Accelerator driven Sub-critical system (ADS) for waste management.

(5 Lectures)

Unit 5

Application of nuclear techniques: Application in medical science (e.g., MRI, PET, Projection Imaging Gamma Camera, radiation therapy), Archaeology, Art, Crime detection, Mining and oil. Industrial Uses: Tracing, Gauging, Material Modification, Sterilization, Food preservation.

(5 Lectures)

Practical : (60 Hours)
PRACTICALS SEC LAB: Radiation Safety

Sessions on the construction and use of specific measurement instruments and experimental apparatuses used in the physics lab, including necessary precautions.

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. Application to the specific experiments done in the lab.

Teacher may give long duration project based on this paper.

Experiments:

At least 05 Experiments from the following

1. Estimate the energy loss of different projectiles/ions in Water and carbon, using SRIM/TRIM etc. simulation software.
2. Simulation study (using SRIM/TRIM or any other software) of radiation depth in materials (Carbon, Silver, Gold, Lead) using H as projectile/ion.
3. Comparison of interaction of projectiles with $Z_P = 1$ to 92 (where Z_P is atomic number of projectile/ion) in a given medium (Mylar, Carbon, Water) using simulation software (SRIM etc).
4. SRIM/TRIM based experiments to study ion-matter interaction of heavy projectiles on heavy atoms. The range of investigations will be $Z_P = 6$ to 92 on $Z_A = 16$ to 92 (where Z_P and Z_A are atomic numbers of projectile and atoms respectively). Draw and infer appropriate Bragg Curves.
5. Calculation of absorption/transmission of X-rays, γ-rays through Mylar, Be, C, Al, Fe and $Z_A = 47$ to 92 (where Z_A is atomic number of atoms to be investigated as targets) using XCOM, NIST (https://physics.nist.gov/PhysRefData/Xcom/html/xcom1.html).
6. Study the background radiation in different places and identify the source material from gamma ray energy spectrum. (Data may be taken from the Department of Physics & Astrophysics, University of Delhi and gamma ray energies are available in the website http://www.nndc.bnl.gov/nudat2/).
7. Study the background radiation levels using Radiation meter .
8. Study of characteristics of GM tube and determination of operating voltage and plateau length using background radiation as source (without commercial source).
9. Study of counting statistics using background radiation using GM counter.
10. Study of radiation in various materials (e.g. KSO_4etc.). Investigation of possible radiation in different routine materials by operating GM counter at operating voltage.
11. Study of absorption of beta particles in Aluminum using GM counter.
12. Detection of α particles using reference source & determining its half life using spark counter.
13. Gamma spectrum of Gas Light mantle (Source of Thorium).

References for Theory

Essential Readings

1. Nuclear Physics by S N Ghoshal, First edition, S. Chand Publication, 2010.
2. Nuclear Physics: Principles and Applications by J Lilley, Wiley Publication, 2006.
3. Fundamental Physics of Radiology by W J Meredith and J B Massey, John Wright and Sons, UK, 1989.
4. An Introduction to Radiation Protection by A Martin and S A Harbisor, John Willey & Sons, Inc. New York, 1981.
5. IAEA Publications: (a) General safety requirements Part 1, No. GSR Part 1 (2010), Part 3 No. GSR Part 3 (Interium) (2010); (b) Safety Standards Series No. RS-G-1.5 (2002), Rs-G-1.9 (2005), Safety Series No. 120 (1996); (c) Safety Guide GS-G-2.1 (2007).

Additional readings

1. Basic ideas and concepts in Nuclear Physics: An introductory approach by K Heyde, third edition, IOP Publication, 1999.
2. Radiation detection and measurement by G F Knoll, 4th Edition, Wiley Publications, 2010.
3. Techniques for Nuclear and Particle Physics experiments by W R Leo, Springer, 1994.
4. Thermoluminescence dosimetry by A F Mcknlay, Bristol, Adam Hilger (Medical Physics Hand book 5.
5. Medical Radiation Physics by W R Hendee, Year book Medical Publishers, Inc., London, 1981.
6. Physics and Engineering of Radiation Detection by S N Ahmed, Academic Press Elsevier, 2007.
7. Nuclear and Particle Physics by W E Burcham and M Jobes, Harlow Longman Group, 1995.

Reference for laboratory work

1. Schaum's Outline of Modern Physics, McGraw-Hill, 1999.
2. Schaum's Outline of College Physics, by E. Hecht, 11^{th} edition, McGraw Hill, 2009.
3. Modern Physics by K Sivaprasath and R Murugeshan, S Chand Publication, 2010.
4. AERB Safety Guide (Guide No. AERB/RF-RS/SG-1), Security of radioactive sources in radiation facilities, 2011.
5. AERB Safety Standard No. AERB/SS/3 (Rev. 1), Testing and Classification of sealed Radioactivity Sources., 2007.

SEC: Applied Optics (32223908)
Credit:04 (Theory-02, Practical-02)
Theory: 30 Hours
Practical: 60 Hours

Course Objective

This paper provides the conceptual understanding of various branches of modern optics to the students. This course introduces basic principles of LASER, Holography and signal transmission via optical fiber.

Course Learning Outcomes

Students will be able to :

- Understand basic lasing mechanism qualitatively, types of lasers, characteristics of laser light and its application in developing LED, Holography.
- Gain concepts of Fourier optics and Fourier transform spectroscopy.
- Understand basic principle and theory of Holography.
- Grasp the idea of total internal reflection and learn the characteristics of optical fibers.

Unit 1

Photo-sources and Detectors

Lasers: an introduction, Planck's radiation law (qualitative idea), Energy levels, Absorption process, Spontaneous and stimulated emission processes, Theory of laser action, Population of energy levels, Einstein's coefficients and optical amplification, properties of laser beam, Ruby laser, He-Ne laser, and semiconductor lasers; Light Emitting Diode (LED) and photo-detectors.

(9 lectures)

Unit 2

Fourier Optics and Fourier Transform Spectroscopy (Qualitative explanation) Concept of Spatial frequency filtering, Fourier transforming property of a thin lens, Fourier Transform Spectroscopy (FTS): measuring emission and absorption spectra, with wide application in atmospheric remote sensing, NMR spectrometry, and forensic science.

(6 lectures)

Unit 3

Holography

Introduction: Basic principle and theory: recording and reconstruction processes, Requirements of holography- coherence, etc. Types of holograms: The thick or volume hologram, Multiplex hologram, white light reflection hologram; application of holography in microscopy, interferometry, and character recognition.

(6 lectures)

Unit 4

Photonics: Fibre Optics

Optical fibres: Introduction and historical remarks, Total Internal Reflection, Basic characteristics of the optical fibre: Principle of light propagation through a fibre, the coherent bundle, The numerical aperture, Attenuation in optical fibre and attenuation limit; Single mode and multimode fibres, Fibre optic sensors: Fibre Bragg Grating.

(9 lectures)

Practical : (60 Hours)
PRACTICALS SEC LAB: Applied Optics

Sessions on the construction and use of specific measurement instruments and experimental apparatuses used in the physics lab, including necessary precautions.

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. Application to the specific experiments done in the lab.

Teacher may give long duration project based on this paper.

Experiments on Lasers:

1. To determine the grating radial spacing of the Compact Disc (CD) by reflection using He-Ne or solid state laser.
2. To find the width of the wire or width of the slit using diffraction pattern obtained by a He-Ne or solid state laser.
3. To find the polarization angle of laser light using polarizer and analyzer d. Thermal expansion of quartz using laser.
4. To determine the wavelength and angular spread of laser light by using plane diffraction grating.

Experiments on Semiconductor Sources and Detectors:

5. V-I characteristics of LED.
6. Study the characteristics of solid state laser.
7. Study the characteristics of LDR.
8. Characteristics of Photovoltaic Cell/ Photodiode. e. Characteristics of IR sensor.

Experiments on Fourier Optics:

9. Optical image addition/subtraction.
10. Optical image differentiation.
11. Fourier optical filtering.
12. Construction of an optical 4f system

Experiments on Fourier Transform Spectroscopy:

To study the interference pattern from a Michelson interferometer as a function of mirror separation in the interferometer. The resulting interferogram is the Fourier transform of the power spectrum of the source. Analysis of experimental interferograms allows one to determine the transmission characteristics of several interference filters. Computer simulation can also be done.

Experiments on Holography and interferometry:

13. Recording and reconstruction of holograms (Computer simulation can also be done).
14. To construct a Michelson interferometer or a Fabry Perot interferometer.
15. To determine the wavelength of sodium light by using Michelson's interferometer.
16. To measure the refractive index of air.

Experiments on Fibre Optics:

17. To measure the numerical aperture of an optical fibre.
18. To measure the near field intensity profile of a fibre and study its refractive index profile.
19. To study the variation of the bending loss in a multimode fibre.
20. To determine the power loss at a splice between two multimode fibre.
21. To determine the mode field diameter (MFD) of fundamental mode in a single-mode fibre by measurements of its far field Gaussian pattern.

References

Essential Readings

1. LASERS: Fundamentals & applications, K. Thyagrajan & A. K. Ghatak, 2010, Tata McGraw Hill
2. Introduction to Fourier Optics, Joseph W. Goodman, The McGraw- Hill, 1996.
3. Introduction to Fiber Optics, A. Ghatak & K. Thyagarajan, Cambridge University Press.
4. Fibre optics through experiments, M.R.Shenoy, S.K.Khijwania, et. al. 2009, Viva Books
5. Optics, Karl Dieter Moller, Learning by computing with model examples, 2007, Springer.

Additional Readings

1. Optical Electronics, Ajoy Ghatak and K. Thyagarajan, 2011, Cambridge University Press
2. Optoelectronic Devices and Systems, S.C. Gupta, 2005, PHI Learning Pvt. Ltd.

SEC: Weather Forecasting (32223909)
Credit:04 (Theory-02, Practical-02)
Theory: 30 Hours
Practical: 60 Hours

Course Objective

- The aim of this course is to impart theoretical knowledge to the students and also to enable them to develop an awareness and understanding of the causes and effects of different weather phenomena and basic forecasting techniques.

Course Learning Outcomes

The student will gain the following:

- Acquire basic knowledge of the elements of the atmosphere, its composition at various heights, variation of pressure and temperature with height.
- Learn basic techniques to measure temperature and its relation with cyclones and anti-cyclones.
- Knowledge of simple techniques to measure wind speed and its directions, humidity and rainfall.
- Understanding of absorption, emission and scattering of radiations in atmosphere; Radiation laws.
- Knowledge of global wind systems, jet streams, local thunderstorms, tropical cyclones, tornadoes and hurricanes.
- Knowledge of climate and its classification. Understanding various causes of climate change like global warming, air pollution, aerosols, ozone depletion, acid rain.
- Develop skills needed for weather forecasting, mathematical simulations, weather forecasting methods, types of weather forecasting, role of satellite observations in weather forecasting, weather maps etc. Uncertainties in predicting weather based on statistical analysis.
- Develop ability to do weather forecasts using input data.
- In the laboratory course, students should be able to learn: Principle of the working of a weather Station, Study of Synoptic charts and weather reports, Processing and analysis of weather data, Reading of Pressure charts, Surface charts, Wind charts and their analysis.

Unit 1

Introduction to atmosphere: Elementary idea of atmosphere: physical structure and composition; compositional layering of the atmosphere; variation of pressure and temperature with height; air temperature; requirements to measure air temperature; temperature sensors: types; atmospheric pressure: its measurement

(9 Periods)

Unit 2

Measuring the weather: Wind; forces acting to produce wind; wind speed direction: units, its direction; measuring wind speed and direction; humidity, clouds and rainfall, radiation: absorption, emission and scattering in atmosphere; radiation laws.

(4 Periods)

Unit 3

Weather systems: Global wind systems; air masses and fronts: classifications; jet streams; local thunderstorms; tropical cyclones: classification; tornadoes; hurricanes.

(3 Periods)

Unit 4

Climate and Climate Change: Climate: its classification; causes of climate change; global warming and its outcomes; air pollution and its measurement, particulate matters PM 2.5, PM 10. Health hazards due to high concentration of PM2.5; aerosols, ozone depletion

(6 Periods)

Unit 5

Basics of weather forecasting: Weather forecasting: analysis and its historical background; need of measuring weather; types of weather forecasting; weather forecasting methods; criteria of choosing weather station; basics of choosing site and exposure; satellites observations in weather forecasting; weather maps; uncertainty and predictability; probability forecasts.

(8 Periods)

Practical : (60 Hours)
PRACTICALS SEC LAB: Weather Forecasting

Real time demonstration of clouds location and their movements based on short-time animation. Satellite, for instance INSAT-3D products can be displayed. Water vapours, cloud imagery & 3D overview of wind pattern can be demonstrated. Different wavelengths channels (Infra-red and Visible) operations can be shown to distinguish the features.
Profiles of different atmospheric parameters (temperature, humidity, wind component, etc.) can be demonstrated based on radiosonde daily launch.

Teacher may give long duration project based on this paper.

Demonstrations and Experiments:
1. Study of synoptic charts & weather reports, working principle of weather station.
2. Processing and analysis of weather data:
    (a) To calculate the sunniest time of the year.
    (b) To study the variation of rainfall amount and intensity.
    (c) To observe the sunniest/driest day of the week.
    (d) To examine the maximum and minimum temperature throughout the year.
    (e) To evaluate the relative humidity of the day.
    (f) To examine the rainfall amount month wise.

3. Exercises in chart reading: Plotting of constant pressure charts, surfaces charts, upper wind charts and its analysis.
4. Formats and elements in different types of weather forecasts/ warning (both aviation and non-aviation).
5. Simulation of weather system
6. Field visits to India Meteorological department and National center for medium range weather forecasting

References

Essential Readings

1. Aviation Meteorology, I.C. Joshi, 3rd edition 2014, Himalayan Books
2. The weather Observers Hand book, Stephen Burt, 2012, Cambridge University Press.
3. Meteorology, S.R. Ghadekar, 2001, Agromet Publishers, Nagpur.
4. Text Book of Agrometeorology, S.R. Ghadekar, 2005, Agromet Publishers, Nagpur.
5. Atmosphere and Ocean, John G. Harvey, 1995, The Artemis Press.

SEC : Introduction to Physical Computing (XXX1)
Credit:04 (Theory-02, Practical-02)
Theory: 30 Hours
Practical: 60 Hours

Course Objective

Exposure to the elements of physical computing using embedded computers to enable the student to implement experimental setups in physics. To offer an opportunity to learn automation and to design an appropriate system for laboratory experiments using computer software in a project based learning environment.

Course Learning Outcomes

The student will be able to

- Understand the evolution of the CPU from microprocessor to microcontroller and embedded computers from a historical perspective.

- Operate basic electronic components and analog and digital electronics building blocks including power supply and batteries.
- Use basic laboratory equipment for measurement and instrumentation.
- Understand the Arduino ecosystem and write simple Arduino programs (sketches)
- Understand sensor characteristics and select a suitable sensor for various applications.
- Read digital and analog data and produce digital and analog outputs from an embedded computer.
- Understand how to interface an embedded computer to the physical environment.
- Visualize the needs of a standalone embedded computer and implement a simple system using Arduino.

Unit 1

Brief overview of a computer. Evolution from CPU to Microprocessor to microcontroller. Introduction to Arduino. Overview of basic electronic components (R, L, C, diode, BJT, MOSFET etc.) and circuits, 555 timer, logic gates, logic function ICs, power supply and batteries.

(4 Lectures)

Unit 2

Capturing schematic diagrams.

(i) Using free software such as Eagle CAD.
(ii)Using basic lab instruments – DMM, oscilloscope, signal generator etc.

(6 Lectures)

Unit 3

Understanding Arduino programming. Downloading and installing Arduino IDE.
Writing an Arduino sketch.
Programming fundamentals: program initialization, conditional statements, loops, functions, global variables.

(5 Lectures)

Unit 4

1. Digital Input and Output
2. Measuring time and events. Pulse Width Modulation.

(6 Lectures)

Unit 5

1. Analog Input and Output.
2. Physical Interface: sensors and actuators.

(6 Lectures)

Unit 6

1. Communication with the outside world.
2. System Integration and debugging.

(**3 Lectures)**

Practical : (60 Hours)
PRACTICALS SEC LAB: Introduction to Physical Computing

Sessions on the construction and use of specific equipment and experimental apparatuses used in the physics lab, including necessary precautions.

Sessions on the review of experimental data analysis, error analysis and reporting and their application to the specific experiments done in the lab.

Teacher may give long duration project based on this paper.

- Hello LED: Connect a LED to a digital output pin and turn it on and off.
- Hello Switch: Read a switch a toggle an LED when the switch is pressed and released.
- Hello ADC: Connect a potentiometer to an ADC input and print the analog voltage on the serial monitor.
- Hello Blink: Read a switch and changing the LED blink rate every time the switch is pressed and released.
- Hello PWM: Write a Pulse Width Modulation code in software and vary the LED intensity.
- Hello Random: Read a switch and every time the switch is pressed and released, generate and print a random number on the serial monitor.
- Hello Random2: Connect a Seven Segment Display (SSD) and print the random number on this display each time a switch is pressed and released. Collect large data sample and plot relative frequency of occurrence of each 'random' number
- Hello LCD: Connect a (16X2) LCD to an Arduino and print 'Hello World'.
- Hello LCD2: Connect a temperature sensor to an ADC input and print the temperature on the LCD
- Hello PWM2: Connect a RGB LED and 3 switches. Use hardware PWM feature of the Arduino and change the relative intensity of each of the LEDs of the RGB LED and generate large number of colors.

Mini Projects:

1. Connect 2 SSDs and every time a switch is pressed and released, print 2 random numbers on the two SSDs
2. Connect a switch and 4 RGB LEDs in a 'Y' configuration. Change the LED lighting patterns each time a switch is pressed and released (total 4095 patterns possible).
3. Arrange acrylic mirrors in a triangle and make a LED kaleidoscope using the RGB LEDs as the light source.
4. Connect a photo-gate mechanism to a bar pendulum. Verify that the period of oscillation is independent of the amplitude for small amplitudes. What happens when the amplitude is large?
5. Connect 8 switches and a small speaker and an audio amplifier and make a piano.
6. Connect 2 sets of 3 switches for two players. Connect LCD and implement a 'rock-paper-scissors' game.

References

Essential Readings

1. Learn Electronics with Arduino: An Illustrated Beginner's Guide to Physical Computing. Jody Culkin and Eric Hagan. Shroff Publishers. ISBN: 9789352136704.
2. Programming Arduino: Getting Started with Sketches, Second Edition. Simon Monk. McGraw-Hill Education. ISBN-10: 1259641635.
3. Physical Computing: Sensing and Controlling the Physical World with Computers, 1st Edition. Thomson. ISBN-10: 159200346X.
4. The Art of Electronics. Paul Horowitz and Winfield Hill. Cambridge University Press. 2^{nd} Edition. ISBN-13: 978-0521689175
5. Designing Embedded Hardware. John Catsoulis. Shroff Publishers. 2^{nd} Edition. ISBN: 9788184042597

SEC: Numerical Analysis (XXX2)
Credit:04 (Theory-02, Practical-02)
Theory: 30 Hours
Practical: 60 Hours

Course Objective

The emphasis of course is to equip students with the mathematical tools required in solving problem of interest to physicists. To expose students to fundamental computational physics skills and hence enable them to solve a wide range of physics problems. To help students develop critical skills and knowledge that will prepare them not only for doing fundamental and applied research but also prepare them for a wide variety of careers.

Course Learning Outcomes

Theory:

After completing this course, student will be able to:

- approximate single and multi-variable function by Taylor's Theorem.
- Solve first order differential equations and apply it to physics problems.

- solve linear second order homogeneous and non-homogeneous differential equations with constant coefficients.
- Calculate partial derivatives of function of several variables
- Understand the concept of gradient of scalar field and divergence and curl of vector fields. perform line, surface and volume integration
- Use Green's, Stokes' and Gauss's Theorems to compute integrals

Practical:

After completing this course, student will be able to :

- design, code and test simple programs in C++ learn Monte Carlo techniques,
- fit a given data to linear function using method of least squares find roots of a given non-linear function
- Use above computational techniques to solve physics problems

Unit 1

Errors and iterative Methods: Truncation and Round-off Errors. Floating Point Computation, Overflow and underflow. Single and Double Precision Arithmetic, Iterative Methods.

(2 Lectures)

Solutions of Algebraic and Transcendental Equations: (1) Fixed point iteration method, (2) Bisection method, (3) Secant Method, (4) Newton Raphson method, (5) Generalized Newton's method. Comparison and error estimation

(6 Lectures)

Unit 2

Interpolation: Forward and Backward Differences. Symbolic Relation, Differences of a polynomial. Newton's Forward and Backward Interpolation Formulas

(5 Lectures)

Unit 3

Least Square fitting: (1) Fitting a straight line. (2) Non-linear curve fitting: (a) Power function, (b) Polynomial of nth degree, and (c) Exponential Function. (3) Linear Weighed Least square Approximation

(5 Lectures)

Unit 4

Numerical Differentiation: (1) Newton's interpolation Formulas & (2) Cubic Spline Method, Errors in Numeric Differentiation. Maximum and Minimum values of a Tabulated Function

(4 Lectures)

Numerical Integration: Generalized Quadrature Formula. Trapezoidal Rule. Simpson's 1/3 and 3/8 Rules. Weddle's Rule, Gauss-Legendre Formula.

(4 Lectures)

Solution of Ordinary Differential Equations: First Order ODE's: solution of Initial Value problems: (1) Euler's Method, (2) Modified Euler's method

(4 Lectures)

Practical : (60 Hours)
PRACTICALS SEC LAB: Numerical Analysis

Sessions on the review of experimental data analysis, error analysis and reporting and their application to the specific experiments done in the lab.

Teacher may give long duration project based on this paper.

Algebraic and transcendental equation:

1. To find the roots of an algebraic equation by Bisection method.
2. To find the roots of an algebraic equation by Secant method.
3. To find the roots of an algebraic equation by Newton-Raphson method.
4. To find the roots of a transcendental equation by Bisection method. Interpolation
5. To find the forward difference table from a given set of data values.
6. To find a backward difference table from a given set of data values. Curve fitting
7. To fit a straight line to a given set of data values.
8. To fit a polynomial to a given set of data values.
9. To fit an exponential function to a given set of data values.

Differentiation:

10. To find the first and second derivatives near the beginning of the table of values of (x,y).
11. To find the first and second derivatives near the end of the table of values of (x,y). Integration
12. To evaluate a definite integral by trapezoidal rule.
13. To evaluate a definite integral by Simpson 1/3 rule.
14. To evaluate a definite integral by Simpson 3/8 rule.
15. To evaluate a definite integral by Gauss Quadrature rule.

Differential Equations:

16. To solve differential equations by Euler's method.
17. To solve differential equations by modified Euler's method.

References

Essential Readings

1. Elementary Numerical Analysis, K.E.Atkinson, 3rd Edn., 2007 , Wiley India Edition.
2. Introduction to Numerical Analysis, S.S. Sastry, 5th Edn., 2012, PHI Learning Pvt. Ltd.
3. A first course in Numerical Methods, U.M. Ascher & C. Greif, 2012, PHI Learning.

References for Laboratory

1. Schaum's Outline of Programming with C++. J. Hubbard, 2000, McGraw Hill Pub.
2. Numerical Recipes in C++: The Art of Scientific Computing, W.H. Press et.al., 2nd Edn., 2013, Cambridge University Press.
3. An introduction to Numerical methods in C++, Brian H. Flowers, 2009, Oxford University Press.

9.3. DSE Courses Discipline Specific (Physics Elective)

DSE-1A: Elements of Modern Physics (42227529)
Credit: 06 (Theory-04, Practical-02)
Theory: 60 Hours
Practical: 60 Hours

Course Objective

The objective of this course is to teach the physical and mathematical foundations necessary for learning various topics in modern physics which are crucial for understanding atoms, molecules, photons, nuclei and elementary particles. These concepts are also important to understand phenomena in laser physics, condensed matter physics and astrophysics.

Course Learning Outcomes

This course will prepare the students to appreciate and comprehend the following aspects:

- Understand historical basis of quantum mechanics.
- Explain how quantum mechanical concepts answer some of unanswered questions of Classical mechanics such as photoelectric effect, Compton scattering etc.
- Explain inadequacy of Rutherford model, discrete atomic spectra from hydrogen like atoms and its explanation on quantum mechanical basis.
- Demonstrate ability to apply wave-particle duality and uncertainty principle to solve physics problems.
- Explain two slit interference experiment with photons, atoms and particles establishing non-deterministic nature of QM.
- Set up Schrodinger equation for behavior of a particle in a field of force for simple potential and find wave solutions establishing wave-like nature of particles.
- Demonstrate ability to solve 1-D quantum problems including the quantum particle in a box, a well and the transmission and reflection of waves.
- Explain nuclear structure, binding energy, nuclear models and impossibility of an electron being in the nucleus as a consequence of the uncertainty principle.
- Understand radioactivity, radioactive decays, apply radioactive laws to solve related physics problems and Pauli's prediction of neutrino, and the subsequent discovery.

Unit 1

Introduction : Planck's quantum, Planck's constant and light as a collection of photons ; Photo- electric effect and Compton scattering. De Broglie wavelength and matter waves; Davisson-Germer experiment.

(12 Lectures)

Unit 2

Problems with Rutherford model: Instability of atoms and observation of discrete atomic spectra; Bohr's quantization rule and atomic stability; calculation of energy levels for hydrogen-like atoms and their spectra.

(14 Lectures)

Unit 3

Position measurement: Gamma ray microscope thought experiment; Wave-particle duality, Heisenberg uncertainty principle - impossibility of a particle following a trajectory; Estimating minimum energy of a confined particle using uncertainty principle; Energy-time uncertainty principle.

(6 Lectures)

Unit 4

Double-slit interference experiment with photons, atoms and particles; linear superposition principle as a consequence; Schrodinger's equation for non-relativistic particles; Momentum and Energy operators; stationary states; physical interpretation of wavefunction, probabilities and normalization; Probability and probability current densities in one dimension.

(11 Lectures)

Unit 5

One dimensional infinitely rigid box: energy eigenvalues, eigenfunctions and their normalization; Quantum dot as an example; Quantum mechanical scattering and tunneling in one dimension - across a step potential and across a rectangular potential barrier. (12 Lectures) Size and structure of atomic nucleus and its relations with atomic weight; Impossibility of an electron being in the nucleus as a consequence of the uncertainty principle. Nature of nuclear force, NZ graph, semi-empirical mass formula & binding energy.

(6 Lectures)

Unit 6

Radioactivity: stability of the nucleus; Law of radioactive decay; Mean life and half-life; Alpha decay; Beta decay: energy released, spectrum and Pauli's prediction of neutrino; Gamma ray emission, energy-momentum conservation: electron-positron pair creation by gamma photons in the vicinity of a nucleus.
Fission and fusion: mass deficit, relativity and generation of energy; Fission: nature of fragments and emission of neutrons.

(11 Lectures)

PRACTICAL (60 Hours)
PHYSICS LAB: DSE-1A LAB:

Sessions on the construction and use of specific measurement instruments and experimental apparatuses used in the modern physics lab, including necessary precautions.

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. Application to the specific experiments done in the lab.

At least 05 experiments from the following:

1. To determine value of Boltzmann constant using V-I characteristic of PN diode.
2. To determine work function of material of filament of directly heated vacuum diode.
3. To determine value of Planck's constant using LEDs of at least 4 different colours.
4. To determine the ionization potential of mercury.
5. To determine the wavelength of H-alpha emission line of Hydrogen atom.
6. To determine the absorption lines in the rotational spectrum of Iodine vapour.
7. To study the diffraction patterns of single and double slits using laser source and measure its intensity variation using Photosensor and compare with incoherent source – Na light. 19
8. Photo-electric effect: photo current versus intensity and wavelength of light; maximum energy of photoelectrons versus frequency of light.
9. To determine the value of e/m by magnetic focusing.

Reference for Theory:

Essential Readings

1. Concepts of Modern Physics, Arthur Beiser, 2002, McGraw-Hill.
2. Modern Physics by R A Serway, C J Moses and C A Moyer, 3rd edition, Thomson Brooks Cole, 2012.
3. Modern Physics for Scientists and Engineers by S T Thornton and A Rex, 4th edition, Cengage Learning, 2013.
4. Basic ideas and concepts in Nuclear Physics: An introductory approach by K Heyde, third edition, IOP Publication, 1999.
5. Quantum Mechanics, Robert Eisberg and Robert Resnick, 2ndEdn., 2002, Wiley.

Additional Readings:

1. Six Ideas that Shaped Physics: Particle Behave like Waves, T.A. Moore,2003, McGraw Hill.
2. Thirty years that shook physics: the story of quantum theory, George Gamow, Garden City, NY: Doubleday, 1966.
3. New Physics, ed. Paul Davies, Cambridge University Press (1989).
4. Quantum Theory, David Bohm, Dover Publications, 1979.
5. Lectures on Quantum Mechanics: Fundamentals and Applications, eds. A. Pathak and Ajoy Ghatak, Viva Books Pvt. Ltd., 2019
6. QUANTUM MECHANICS: Theory and Applications, (2019), (Extensively revised 6th Edition), Ajoy Ghatak and S. Lokanathan, Laxmi Publications, New Delhi
7. Concepts of Nuclear Physics by B L Cohen, Tata McGraw Hill Publication, 1974.

Reference for Laboratory work

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

2. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers.
3. A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Edition,2011, Kitab Mahal, New Delhi.
4. An Advanced Course in Practical Physics, D. Chattopadhyay & P. C. Rakshit, 2013, New Book Agency (P) Ltd.
5. Practical Physics, G.L. Squires, 2015, 4th Edition, Cambridge University Press.

DSE-1A: Digital, Analog and Instrumentation (42227530)
Credit: 06 (Theory-04, Practical-02)
Theory: 60 Hours
Practical: 60 Hours

Course Objective

This paper aims to cover the basic digital and analog electronic systems. The concept of Boolean algebra is discussed in detail and arithmetic circuits are described. Students will learn the physics of semiconductor devices such as p-n junction, rectifier diodes and bipolar junction transistors.

Course Learning Outcomes

- Differentiating the Analog and Digital circuits, the concepts of number systems like Binary, BCD, Octal and hexadecimal are developed to elaborate and focus on the digital systems.
- Characteristics and working of pn junction.
- Two terminal devices: Rectifier diodes, Zener diode, photodiode etc.
- NPN and PNP transistors: Characteristics of different configurations, biasing, stabilization and their applications.
- CE and two stage RC coupled transistor amplifier using h-parameter model of the transistor.
- Designing of different types of oscillators and their stabilities.
- Ideal and practical op-amps: Characteristics and applications.
- Timer circuits using IC 555 providing clock pulses to sequential circuits and develop multivibrators.

- Also impart understanding of working of CRO and its usage in measurements of voltage, current, frequency and phase measurement.
- In the laboratory students will learn to construct both combinational and sequential circuits by employing NAND as building blocks. They will be able to study characteristics of various diodes and BJT. They will also be able to design amplifiers (using BJT and Op-Amp), oscillators and multivibrators. They will also learn working of CRO.

Unit 1

Digital Circuits

Difference between Analog and Digital Circuits. Binary Numbers. Decimal to Binary and Binary to Decimal Conversion, AND, OR and NOT Gates. NAND and NOR. Gates as Universal Gates. XOR and XNOR Gates.

(5 Lectures)

De Morgan's Theorems. Boolean Laws. Simplification of Logic Circuit using Boolean Algebra. Fundamental Products. Minterms and Maxterms. Conversion of a Truth Table into an Equivalent Logic Circuit by (1) Sum of Products Method and (2) Karnaugh Map.

(6 Lectures)

Binary Addition. Binary Subtraction using 2's Complement Method). Half Adders and Full Adders and Subtractors, 4-bit binary Adder-Subtractor.

(4 Lectures)

Unit 2

Semiconductor Devices and Amplifiers: Semiconductor Diodes: P and N type semiconductors. PN junction and its characteristics. Static and dynamic Resistance.

(2 Lectures)

Bipolar Junction transistors: n-p-n and p-n-p Transistors. Characteristics of CB, CE and CC Configurations. Active, Cutoff & Saturation regions. Current gains α and β. Relations between α and β. Load Line analysis of Transistors. DC Load line & Q-point. Voltage Divider Bias Circuit for CE Amplifier. h-parameter Equivalent Circuit of transistor. Analysis of single-stage CE amplifier using hybrid Model. Input and output Impedance. Current and Voltage gains.

(12 Lectures)

Unit 3

Operational Amplifiers (Black Box approach): Characteristics of an Ideal and Practical Op-Amp (IC 741), Open-loop and closed-loop Gain. CMRR, concept of Virtual ground. Applications of Op-Amps: (1) Inverting and non-inverting Amplifiers, (2) Adder, (3) Subtractor, (4) Differentiator, (5) Integrator, (6) Zero crossing detector.

(14 Lectures)

Sinusoidal Oscillators: Barkhausen's Criterion for Self-Sustained Oscillations. Determination of Frequency of RC Phase-shift Oscillator.

(5 Lectures)

Unit 4

Instrumentations :

Introduction to CRO: Block diagram of CRO. Applications of CRO: (1) Study of waveform, (2) Measurement of voltage, current, frequency, and phase difference.

(3 Lectures)

Power Supply: Half-wave Rectifiers. Centre-tapped and Bridge Full-wave Rectifiers, Calculation of Ripple Factor and Rectification Efficiency, Basic idea about capacitor filter, Zener Diode and Voltage Regulation.

(6 Lectures)

Timer IC: IC 555 Pin diagram and its application as Astable and Monostable Multivibrator.

(3 Lectures)

PRACTICAL (60 Hours)
PHYSICS LAB: DSE-1A LAB: Digital, Analog and Instrumentation

Session on the construction and use of CRO, and other experimental apparatuses used in the lab, including necessary precautions.

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. Application to the specific experiments done in the lab.

At least 06 experiments from the following:

1. To measure (a) Voltage, and (b) Frequency of a periodic waveform using a CRO
2. To minimize a given (a) logic circuit and (b) Boolean equation.
3. Half adder, Full adder and 4-bit Binary Adder.
4. To design an astable multivibrator of given specifications using 555 Timer.
5. To design a monostable multivibrator of given specifications using 555 Timer.
6. To study IV characteristics of (a) PN diode, (b) Zener diode and (c) LED
7. To study the characteristics of a Transistor in CE configuration.
8. To design a CE amplifier of a given gain (mid-gain) using voltage divider bias.
9. To design an inverting amplifier of given gain using Op-amp 741 and study its frequency response. (b) To design a non-inverting amplifier of given gain using Op-amp 741 and study its Frequency Response.
10. To study a precision Differential Amplifier of given I/O specification using Op-amp.
11. To investigate the use of an op-amp as a Differentiator.
12. To design a Wien Bridge Oscillator using an op-amp.

References for Theory

Essential Readings

1. Integrated Electronics, J. Millman and C.C. Halkias, 1991, Tata Mc-Graw Hill.
2. Fundamentals of Digital Circuits, Anand Kumar, 4th Edn, 2018, PHI Learning Pvt. Ltd.
3. Digital Principles and Applications, A.P.Malvino, D.P.Leach and Saha, 8th Ed., 2018, Tata McGraw Hill Education.

4. OP-AMP & Linear Digital Circuits, R.A. Gayakwad, 2000, PHI Learning Pvt. Ltd.
5. Electronics: Fundamentals and Applications, J.D. Ryder, 2004, Prentice Hall.

Additional Readings

1. Electronic devices & circuits, S. Salivahanan & N.S. Kumar, 2012, Tata Mc-Graw Hill
2. Microelectronic Circuits, M.H. Rashid, 2nd Edn., 2011, Cengage Learning.
3. Modern Electronic Instrumentation and Measurement Tech., Helfrick and Cooper,1990, PHI Learning.
4. Microelectronic circuits, A.S. Sedra, K.C. Smith, A.N. Chandorkar, 2014, 6th Edn., Oxford University Press.

Reference for Laboratory work

1. Electronic Devices and circuits, B. Kumar, S.B. Jain, 2nd Edition, 2015, PHI Learning Pvt. Ltd.
2. Basic Electronics: A text lab manual, P.B.Zbar, A.P.Malvino, M.A.Miller, 1994, Mc-Graw Hill.

DSE-1A: Mathematical Physics (42227531)
Credit: 06 (Theory-04, Practical-02)
Theory: 60 Hours
Practical: 60 Hours

Course Objective

The emphasis of course is to equip students with the mathematical tools required in solving problem of interest to physicists. The course will expose students to fundamental computational physics skills and hence enable them to solve a wide range of physics problems.

Course Learning Outcomes

At the end of this course, the students will be able to

- Find extrema of functions of several variables.

- Represent a periodic function by a sum of harmonics using Fourier series and their applications in physical problems such as vibrating strings etc.
- Obtain power series solution of differential equation of second order with variable coefficient using Frobenius method.
- Understand properties and applications of special functions like Legendre polynomials, Bessel functions and their differential equations and apply these to various physical problems such as in quantum mechanics.
- Learn about gamma and beta functions and their applications.
- Solve linear partial differential equations of second order with separation of variable method.
- Understand the basic concepts of complex analysis and integration.
- In the laboratory course, the students will be able to design, code and test simple programs in C++ in the process of solving various problems.

Unit 1

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

(6 Lectures)

Fourier Series: Periodic functions. Orthogonality of sine and cosine functions, Dirichlet Conditions (Statement only). Expansion of periodic functions in a series of sine and cosine functions and determination of Fourier coefficients. Even and odd functions and their Fourier expansions. Application. Summing of Infinite Series.

(10 Lectures)

Unit 2

Frobenius Method and Special Functions: Singular Points of Second Order Linear Differential Equations and their importance. Frobenius method and its applications to differential equations. Legendre, Bessel Differential Equations. Properties of Legendre Polynomials: Rodrigues Formula, Orthogonality. Simple recurrence relations.

(16 Lectures)

Unit 3

Some Special Integrals: Beta and Gamma Functions and Relation between them. Expression of Integrals in terms of Gamma Functions.

(4 Lectures)

Partial Differential Equations: Solutions to partial differential equations, using separation of variables: Laplace's Equation in problems of rectangular geometry. Solution of 1D wave equation.

(10 Lectures)

Unit 4

Complex Analysis: Brief revision of Complex numbers & their graphical representation. Euler's formula, D-Moivre’s theorem, Roots of Complex Numbers. Functions of Complex Variables. Analyticity and Cauchy-Riemann Conditions. Examples of analytic functions. Singular functions: poles and branch points, order of singularity. Integration of a function of a complex variable. Cauchy’s Integral.

(14 Lectures)

PRACTICAL (60 Hours)
PHYSICS LAB: DSE-1A LAB: Mathematical Physics

The aim of this Lab is not just to teach computer programming and numerical analysis but to eemphasize its role in solving problems in Physics.

- Highlights the use of computational methods to solve physics problems.
- The course will consist of lectures (both theory and practical) in the Lab. The recommended group size is not more than 15 students.
- Evaluation to be done not on the programming but on the basis of formulating the problem.
- Aim at teaching students to construct the computational problem to be solved.
- Students can use any one operating system: Linux or Microsoft Windows.
- At least 12 programs must be attempted from the following covering the entire syllabus.
- The list of programs here is only suggestive. Students should be encouraged to do.

Topics	**Descriptions with Applications**
Introduction and Overview	Computer architecture and organization, memory and Input/output devices,
Basics of scientific computing	Binary and decimal arithmetic, Floating point numbers, single and double precision arithmetic, underflow and overflow - emphasize the importance of making equations in terms of dimensionless variables, Iterative methods
Algorithms and Flow charts	Purpose, symbols and description,

Introduction to C++	Introduction to Programming: Algorithms: Sequence, Selection and Repetition, Structured programming, basic idea of Compilers. Data Types, Enumerated Data, Conversion & casting, constants and variables, Mathematical, Relational, Logical and Bit wise Operators. Precedence of Operators, Expressions and Statements, Scope and Visibility of Data, block, Local and Global variables, Auto, static and External variables. Programs: • To calculate area of a rectangle • To check size of variables in bytes (Use of size of () Operator) • converting plane polar to Cartesian coordinates and vice versa
C++ Control Statements	if-statement, if-else statement, Nested if Structure, Else-if statement, Ternary operator, Goto statement, switch statement, Unconditional and Conditional looping, while loop, Do-while loop, for loop, nested loops, break and continue statements Programs: • To find roots of a quadratic equation if…else and if…else if. Else • To find largest of three numbers • To check whether a number is prime or not • To list Prime numbers up to 1000
Random Number generator	Generating pseudo random numbers to find value of pi using Monte Carlo simulations. To integrate using Monte Carlo Method
Arrays and Functions	Sum and average of a list of numbers, largest of a given list of numbers and its location in the list, sorting of numbers in ascending descending order using Bubble sort and Sequential sort, Binary search, 2-dimensional arrays, matrix operations (sum, product, transpose etc.)

Solution of Algebraic and Transcendental equations by Bisection, Newton Raphson and Secant methods	Solution of linear and quadratic equation, solving $\alpha = \tan\alpha; I = I_0\left(\frac{\sin\alpha}{\alpha}\right)^2$ in optics, square root of a number.
Data Analysis and Least Square Fitting (Linear case)	Uncertainty, error and precision, mean, standard deviation and error in the mean. Combining uncertainties (law of propagation of error), Least squares method for fitting data: linear (y=ax+b), power law($y=ax^b$) and exponential ($y=ae^{bx}$). To find parameters a, b and errors in them using method of least squares. Ohms law- calculate R, Hooke's law - Calculate spring constant.
Taylor's and Maclaurin Series	Finding approximate value of sin(x) or cos(x) using first 'n' terms in the series expansion. Finding value of sin(x) accurate to a given number of significant digits.
Numerical differentiation (Forward and Backward and central difference formulae – Using basic definition)	Given Position with equidistant time data calculate velocity and acceleration

References for Theory:

Essential Readings

1. Advanced Engineering Mathematics, Erwin Kreyszig, 2008, Wiley India.
2. Complex Variables and Applications, J.W.Brown& R.V.Churchill, 7th Ed. 2003, Tata McGraw-Hill.
3. Advanced Mathematics for Engineers and Scientists: Schaum Outline Series, M. R Spiegel, McGraw Hill Education (2009).

4. Applied Mathematics for Engineers and Physicists, L.A. Pipes and L.R. Harvill, Dover Publications (2014).
5. Mathematical Methods for Physics and Engineers, K.F Riley, M.P. Hobson and S. J. Bence, 3rd ed., 2006, Cambridge University Press

Additional Readings:

1. Mathematical Physics, A.K. Ghatak, I.C. Goyal and S.J. Chua, Laxmi Publications Private Limited (2017)
2. Advanced Engineering Mathematics ,D.G.Zill and W.S.Wright, 5 Ed.,2012,Jones and Bartlett Learning.
3. An introduction to ordinary differential equations, E.A.Coddington, 2009, PHI learning. Differential Equations, George F. Simmons, 2007, McGraw Hill.
4. Mathematical methods for Scientists & Engineers, D.A.Mc Quarrie, 2003, Viva Books

Reference for Laboratory work:

1. C++ How to Program', Paul J. Deitel and Harvey Deitel, Pearson (2016)
2. '**Schaum's** Outline of Programming with C++', J.Hubbard, 2000, McGraw-Hill Education
3. Introduction to Numerical Analysis, S.S. Sastry, 5th Edn., 2012, PHI Learning Pvt. Ltd.
4. An introduction to Numerical methods in C^{++}, Brian H. Flowers, 2009, Oxford University Press.
5. Computational Physics, Darren Walker, 1st Edn., Scientific International Pvt. Ltd (2015).
6. Elementary Numerical Analysis, K.E. Atkinson, 3rd Edn., 2007, Wiley India Edition.

DSE-1A: Nano Materials and Applications (42227532)
Credit: 06 (Theory-04, Practical-02)
Theory: 60 Hours
Practical: 60 Hours

Course Objective

This course introduces briefly the basic concepts of Quantum Mechanics and principles required to understand nanomaterials. Various nanomaterial synthesis/growth methods and characterizations techniques are discussed to explore the field in detail. The effect of dimensional confinement of charge carries on the electrical, optical and structural properties are discussed.

Course Learning Outcomes

On successful completion of the module students should be able to

- Understand the basic concepts of Quantum Mechanics and solve Schrodinger wave equation for simple problems.
- Explain the difference between nanomaterials and bulk materials and their properties.
- Explain the role of confinement on the density of state function and so on the various properties exhibited by nanomaterials compared to bulk materials.
- Explain various methods for the synthesis/growth of nanomaterials including top down and bottom up approaches.
- Analyze the data obtained from the various characterization techniques.
- Explain various applications of nano particles, quantum dots, nano wires etc.
- Explain why nanomaterials exhibit properties which are sometimes very opposite, like magnetic, to their bulk counterparts.
- In the Lab course students will synthesize nanoparticles by different chemical routes and characterize them in the laboratory using the different techniques, learnt in the theory.
- They will also carry out thin film preparation and prepare capacitors and evaluate its performance. They will fabricate a PN diode and study its I-V characteristics.

Unit 1

Basic Introduction to solids: Classification of solids into crystalline and amorphous materials, classification based on conductivity (range of values) as metals, semiconductors and insulators, idea of bandgap and its consequence on optical and electrical proper es, electrons as free particles for current conduction (I = nevA), introduce bulk (3D) and nanomaterials {thin films (2D), nanowires (1D) nanodots or quantum dots (0D)} with an example of the colour of say Gold metals and its nanoparticles.

(6 Lectures)

Unit 2

Basic Quantum Mechanics: Idea about particles as wave, electron interference experiment, superposition principle, position (or amplitude), and momentum. Wave-particle duality, uncertainty principle, energy quantisation, Schrodinger's equation, Applications of Schrodinger's equation (quantitative): The free particle, potential step, rectangular potential barrier and the tunnel effect free and bound states of a particle in square well potential, particle in a box (3D) problem.

(14 Lectures)

Unit 3

Nanoscale Systems: Bulk materials Density of States function and its implication on electrical properties, Band structure and density of states function for nanoscale materials (Quantitative for 2D, 1D, 0D), Applications of quantum confinement of carriers in 3D, 2D, 1D nanostructures and its consequences on electronic and optical properties.

(10 Lectures)

Unit 4

Synthesis and Characterization (Qualitative): Top down and Bottom up approach, Photolithography. Ball milling. Spin coating, Vacuum deposition: Physical vapor deposition (PVD): Thermal evaporation, Sputtering, Pulsed Laser Deposition (PLD), electric arc deposition for CNT, C_{60}, grapheme, Chemical vapor deposition (CVD). Preparation through colloidal methods (Metals, Metal Oxide nanoparticles), MBE growth of quantum dots.

(**5 Lectures)**

Structure and Surface morphology: X-Ray Diffraction (XRD). Scanning Electron Microscopy (SEM). Transmission Electron Microscopy (TEM).
Spectroscopy: UV-Vis spectroscopy. (Emphasis should be on to discuss data and plots gathered from these techniques).

(11 Lectures)

Unit 5

Optical and Electron Transport Properties: Bandgap tuning as a function of particle size (discuss results of oxide and metal nanoparticles) Radiative processes: General formalization absorption, emission and luminescence. Defects and impurities. Time and length scales of electrons in solids, Carrier transport, diffusive and ballistic transport in nanostrucutures, Charging effect, Coulomb blockade effect.

(12 Lectures)

Unit 6

Applications (Qualitative): based on optical, electrical and magnetic properties of nanoparticles, nanowires and thin films in electronic industry, medical industry, beauty products, Micro Electromechanical Systems (MEMS).

(7 Lectures)

PRACTICAL (60 Hours)
PHYSICS LAB: DSE-1A LAB: Nano Materials and Applications

Sessions on the construction and use of specific measurement instruments and experimental apparatuses used in the nano physics lab, including necessary precautions.

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. Application to the specific experiments done in the lab.

At least 06 experiments from the following:

1. Synthesis of metal (Au/Ag) nanoparticles by chemical route and study its optical absorption properties.
2. Synthesis of semiconductor (CdS/ZnO/TiO2/Fe2O3etc) nanoparticles and study its XRD and optical absorption properties as a function of time.
3. Surface Plasmon study of metal nanoparticles by UV-Visible spectrophotometer.
4. Analysis of XRD pattern of nanomaterials and estimation of particle size.
5. To study the effect of size on color of nanomaterials.
6. To prepare composite of CNTs with other materials.
7. Growth of quantum dots by thermal evaporation.
8. Prepare a disc of ceramic of a compound and study its XRD.
9. Fabricate a thin film of nanoparticles by spin coating (or chemical route) and study its XRD and UV-Visible spectra.
10. Prepare a thin film capacitor and measure capacitance as a function of temperature or frequency.
11. F abricate a PN junction diode by diffusing Al over the surface of N-type Si/Ge and study its V-I characteristic.

References for Theory
Essential Readings

1. Introduction to Nanoelectronics, V.V. Mitin, V.A. Kochelap and M.A. Stroscio, 2011, Cambridge University Press.
2. C.P. Poole, Jr. Frank J. Owens, Introduction to Nanotechnology 1st edition (2003) Wiley India Pvt. Ltd.
3. S.K. Kulkarni, Nanotechnology: Principles & Practices 2nd edition (2011) (Capital Publishing Company)
4. K.K. Chattopadhyay and A. N. Banerjee, Introduction to Nanoscience and Technology (2009) (PHI Learning Private Limited).
5. Electronic transport in mesoscopic systems by Supriyo Datta (1997) Cambridge University Press.

Additional Readings

1. Solid State Physics, M. A. Wahab, 2011, Narosa Publications.
2. Solid State Physics by J. R. Hall and H. E. Hall, 2nd edition (2014) Wiley.

3. Quantum Mechanics by S. P. Singh, M. K. Badge and K. Singh, S. Chand and Company Ltd.
4. Fundamentals of molecular spectroscopy by C. N. Banwell and E. M. McCASH, 4th edition, McGraw-Hill.
5. Quantum Transport in semiconductor nanostructures by Carla Beenakker and HenK Van Houten (1991) (available at arXiv: cond-mat/0412664) open source Sara cronewett Ph.D. thesis (2001).

Reference for Laboratory work

1. C.P. Poole, Jr. Frank J. Owens, Introduction to Nanotechnology 1st edition (2003) Wiley India Pvt.Ltd..
2. S.K. Kulkarni, Nanotechnology: Principles & Practices 2nd edition (2011) (Capital Publishing Company).
3. K.K. Chattopadhyay and A. N. Banerjee, Introduction to Nanoscience and Technology (2009) (PHI Learning Private Limited).
4. Richard Booker, Earl Boysen, Nanotechnology for Dummies (2005) (Wiley Publishing Inc.).

DSE-1A: Communication System (42227533)
Credit: 06 (Theory-04, Practical-02)
Theory: 60 Hours
Practical: 60 Hours

Course Objective

This paper aims to describe the concepts of electronics in communication and communication techniques based on Analog Modulation, Analog and digital Pulse Modulation. Communication and Navigation systems such as GPS and mobile telephony system are also introduced. This paper will essentially connect the text book knowledge with the most popular communication technology in real world.

Course Learning Outcomes

At the end of this course, students will be able to

- Understand of fundamentals of electronic communication system and electromagnetic communication spectrum with an idea of frequency allocation for radio communication system in India.
- Gain an insight on the use of different modulation and demodulation techniques used in analog communication
- Learn the generation and detection of a signal through pulse and digital modulation techniques and multiplexing.
- Gain an in-depth understanding of different concepts used in a satellite communication system.
- Study the concept of Mobile radio propagation, cellular system design and understand mobile technologies like GSM and CDMA.
- Understand evolution of mobile communication generations 2G, 3G, and 4G with their characteristics and limitations.
- In the laboratory course, students will apply the theoretical concepts to gain hands on experience in building modulation and demodulation circuits; Transmitters and Receivers for AM and FM. Also to construct TDM, PAM, PWM, PPM and ASK, PSK and FSK modulator and verify their results.

Unit 1

Electronic communication: Introduction to communication – means and modes. Power measurements (units of power). Need for modulation. Block diagram of an electronic communication system. Brief idea of frequency allocation for radio communication system in India (TRAI). Electromagnetic communication spectrum, band designations and usage. Channels and base-band signals.

(4 Lectures)

Analog Modulation: Amplitude Modulation, modulation index and frequency spectrum. Generation of AM (Emitter Modulation), Amplitude Demodulation (diode detector), Single Sideband (SSB) systems, advantages of SSB transmission, Concept of Single side band generation and detection. Frequency Modulation (FM) and Phase Modulation (PM), modulation index and frequency spectrum, equivalence between FM and PM, Generation of FM using VCO, FM detector (slope detector), Qualitative idea of Super heterodyne receiver.

(12 Lectures)

Unit 2

Analog Pulse Modulation: Channel capacity, Sampling theorem, Basic Principles-PAM, PWM, PPM, modulation and detection technique for PAM only, Multiplexing (time division multiplexing and frequency division multiplexing).

(9 Lectures)

Unit 3

Digital Pulse Modulation: Need for digital transmission, Pulse Code Modulation, Digital Carrier Modulation Techniques, Sampling, Quantization and Encoding. Concept of

Amplitude Shift Keying (ASK), Frequency Shift Keying (FSK), Phase Shift Keying (PSK), and Binary Phase Shift Keying (BPSK).

(10 Lectures)

Unit 4

Satellite Communication : Introduction, need, Geosynchronous satellite orbits, geostationary satellite advantages of geostationary satellites. Transponders (C - Band), Uplink and downlink, path loss, Satellite visibility, Ground and earth stations. Simplified block diagram of earth station.

(10 Lectures)

Unit 5

Mobile Telephony System: Basic concept of mobile communication, frequency bands used in mobile communication, concept of cell sectoring and cell splitting, SIM number, IMEI number, need for data encryption, architecture (block diagram) of mobile communication network, idea of GSM, CDMA, TDMA and FDMA technologies, simplified block diagram of mobile phone handset, 2G, 3G and 4G concepts (qualitative only), GPS navigation system (qualitative idea only.

(15 Lectures)

PRACTICAL (60 Hours)
PHYSICS LAB: DSE-1A LAB: Communication System

Session on the construction and use of CRO, and other experimental apparatuses used in the lab, including necessary precautions.

Sessions on the review of experimental data analysis, error analysis and reporting and their application to the specific experiments done in the lab.

At least 05 experiments from the following:

1. To design an Amplitude Modulator using Transistor
2. To study envelope detector for demodulation of AM signal
3. To study FM - Generator and Detector circuit
4. To study AM Transmitter and Receiver
5. To study FM Transmitter and Receiver
6. To study Time Division Multiplexing (TDM)
7. To study Pulse Amplitude Modulation (PAM)
8. To study Pulse Width Modulation (PWM)
9. To study Pulse Position Modulation (PPM)
10. To study ASK, PSK and FSK modulators

References for Theory

Essential Readings

1. Electronic Communications, D. Roddy and J. Coolen, Pearson Education India.
2. Advanced Electronics Communication Systems- Tomasi, 6thEdn. Prentice Hall.
3. Modern Digital and Analog Communication Systems, B.P. Lathi, 4th Edition, 2011, Oxford University Press.
4. Electronic Communication systems, G. Kennedy, 3rd Edn., 1999, Tata McGraw Hill.
5. Principles of Electronic communication systems – Frenzel, 3rd edition, McGraw Hill

Additional Readings

1. Communication Systems, S. Haykin, 2006, Wiley India
2. Wireless communications, Andrea Goldsmith, 2015, Cambridge University Press

References for Laboratory

1. Electronic Communication system, Blake, Cengage, 5th edition. Wireless communications, Andrea Goldsmith, 2015, Cambridge University Press.
2. Introduction to Communication systems, U. Madhow, 1st Edition, 2018, Cambridge University Press.

DSE-1A: Verilog and FPGA Based System Design (42227534)
Credit: 06 (Theory-04, Practical-02)
Theory: 60 Hours
Practical: 60 Hours

Course Objective

This paper provides a review of combinational and sequential circuits such as multiplexers, demultiplexers, decoders, encoders and adder circuits. It discusses the fundamental Verilog concepts in-lieu of today's most advanced digital design techniques.

Course Learning Outcomes

At the end of this course, students will be able to

- Understand the steps and processes for design of logic circuits and systems.

- Differentiate between combinational and sequential circuits.
- Design various types of state machines..
- Understand various types of programmable logic building blocks such as CPLDs and FPGAs and their tradeoffs.
- Write synthesizable Verilog code.
- Write a Verilog test bench to test various Verilog code modules.
- Design, program and test logic systems on a programmable logic device (CPLD or FPGA) using Verilog.

Unit 1

Digital logic design flow. Review of combinational circuits. Combinational building blocks: multiplexors, demultiplexers, decoders, encoders and adder circuits. Review of sequential circuit elements: flip-flop, latch and register. Finite state machines: Mealy and Moore. Other sequential circuits: shift registers and counters. FSMD (Finite State Machine with Datapath): design and analysis. Microprogrammed control. Memory basics and timing. Programmable Logic devices.

(20 lectures)

Unit 2

Evolution of Programmable logic devices. PAL, PLA and GAL. CPLD and FPGA architectures. Placement and routing. Logic cell structure, Programmable interconnects, Logic blocks and I/O Ports. Clock distribution in FPGA. Timing issues in FPGA design. Boundary scan.

(20 lectures)

Unit 3

Verilog HDL: Introduction to HDL. Verilog primitive operators and structural Verilog Behavioral Verilog. Design verification. Modeling of combinational and sequential circuits (including FSM and FSMD) with Verilog Design examples in Verilog.

(20 lectures)

PRACTICAL (60 Hours)
PHYSICS LAB: DSE-1A LAB: Verilog and FPGA Based System Design

Session on the construction and use of CRO, and other experimental apparatuses used in the lab, including necessary precautions.

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. Application to the specific experiments done in the lab.

At least 05 experiments from the following:

1. Write code to realize basic and derived logic gates.
2. Half adder, Full Adder using basic and derived gates.
3. Half subtractor and Full Subtractor using basic and derived gates.
4. Design and simulation of a 4-bit Adder.

5. Multiplexer (4x1) and Demultiplexer using logic gates.
6. Decoder and Encoder using logic gates.
7. Clocked D, JK and T Flip flops (with Reset inputs).
8. 3-bit Ripple counter.
9. To design and study switching circuits (LED blink shift).
10. To design traffic light controller.
11. To interface a keyboard.
16. To interface a LCD using FPGA.
17. To interface multiplexed seven segment display.
18. To interface a stepper motor and DC motor.
19. To interface ADC 0804.

References for Theory

Essential Readings

1. Principles of Digital Systems Design and VHDL, Lizy Kurien and Charles Roth; Cengage Publishing. ISBN-13:978-8131505748.
2. Verilog HDL, Samir Palnitkar, Pearson Education; Second edition (2003).
3. FPGA Based System Design, Wayne Wolf; Pearson Education,
4. Digital Signal processing, S. K. Mitra; McGraw Hill, 1998
5. VLSI design, Debaprasad Das; Oxford University Press, 2nd Edition, 2015.

Additional Readings

1. Digital Signal Processing with FPGAs, U. Meyer Baese; Springer, 2004
2. Verilog HDL primer- J. Bhasker. BSP, 2003

References for Laboratory

1. Digital System Designs and Practices: Using Verilog HDL and FPGAs, Ming-Bo Lin; Wiley India Pvt Ltd. ISBN-13: 978-8126536948.
2. Verilog Digital System Design, Zainalabedin Navabi; TMH; 2nd edition. ISBN-13: 978-0070252219.
3. Designing Digital Computer Systems with Verilog, D.J. Laja and S. Sapatnekar; Cambridge University Press, 2015.

DSE-1A: Medical Physics (42227535)
Credit: 06 (Theory-04, Practical-02)
Theory: 60 Hours
Practical: 60 Hours

Course Objective

This course introduces a student to the basics of Medical Physics.

Course Learning Outcomes

This course will enable the student to

- Focus on the application of Physics to clinical medicine.
- Gain a broad and fundamental understanding of Physics while developing particular expertise in medical applications.
- Learn about the human body, its anatomy, physiology and BioPhysics, exploring its performance as a physical machine.
- Learn diagnostic and therapeutic applications like the ECG, Radiation Physics, X-ray technology, ultrasound and magnetic resonance imaging.
- Gain knowledge with reference to working of various diagnostic tools, medical imaging techniques
- Understand interaction of ionizing radiation with matter - its effects on living organisms and its uses as a therapeutic technique and also radiation safety practices.
- Gain functional knowledge regarding need for radiological protection and the sources of an approximate level of radiation exposure for treatment purposes.
- In the laboratory course, the student will be exposed to the workings of various medical devices and getting familiarized with various detectors used in medical imaging, medical diagnostics. The hands-on experience will be very useful for the students from job perspective.

Unit 1

PHYSICS OF THE BODY-I

Basic Anatomical Terminology: Standard Anatomical Position, Planes. Familiarity with terms like- Superior, Inferior, Anterior, Posterior, Medial, Lateral, Proximal and Distal. Mechanics of the body: Skeleton, forces, and body stability. Muscles and dynamics of body movement.

Physics of Locomotors Systems: joints and movements, Stability and Equilibrium. Energy household of the body: Energy balance in the body, Energy consumption of the body, Heat losses of the body, Thermal Regulation.

Other Systems in the body: Pressure system of body. Physics of breathing, Physics of cardiovascular system.

(8 Lectures)

Unit 2

PHYSICS OF THE BODY-II

Acoustics of the body: Nature and characteristics of sound, Production of speech, Physics of the ear, Diagnostics with sound and ultrasound. Optical system of the body: Physics of the eye. Electrical system of the body: Physics of the nervous system, Electrical signals and information transfer.

(10 Lectures)

Unit 3

PHYSICS OF DIAGNOSTIC AND THERAPEUTIC SYSTEMS-I

X-Rays: Electromagnetic spectrum, production of x-rays, x-ray spectra, Brehmsstrahlung, Characteristic x-ray. X-ray tubes & types: Coolidge tube, x-ray tube design, tube cooling stationary mode, Rotating anode x-ray tube, Tube rating, quality and intensity of x-ray. X-ray generator circuits, half wave and full wave rectification, filament circuit, kilo voltage circuit. Single and three phase electric supply. Power ratings. Types of X-Ray Generator, high frequency generator, exposure timers and switches, HT cables.

(7 Lectures)

Radiation Physics: Radiation units' exposure, absorbed dose, units: rad, gray, relative biological effectiveness, effective dose- Rem & Sievert, inverse square law. Interaction of radiation with matter Compton & photoelectric effect, linear attenuation coefficient. Radiation Detectors: ionization (Thimble chamber, condenser chamber), chamber. Geiger Muller counter, Scintillation counters and Solid-State detectors, TFT.

(7 Lectures)

Unit 4

MEDICAL IMAGING PHYSICS: Evolution of Medical Imaging-ray diagnostics and imaging, Physics of nuclear magnetic resonance (NMR), NMR imaging, MRI Radiological imaging, Ultrasound imaging, Physics of Doppler with applications and modes, Vascular Doppler. Radiography: Filters, grids, cassette, X-ray film, film processing, fluoroscopy. Computed tomography scanner- principle and function, display, generations, mammography. Thyroid uptake system and Gamma camera (Only Principle, function and display).

(9 Lectures)

RADIATION ONCOLOGY PHYSICS: External Beam Therapy (Basic Idea): Telecobalt, Conformal Radiation Therapy (CRT), 3DCRT, IMRT, Image Guided Radiotherapy, EPID, Rapid Arc, Proton Therapy, Gamma Knife, Cyber Knife. Contact Beam Therapy (Basic Idea): Brachytherapy- LDR and HDR, Intra Operative Brachytherapy. Radiotherapy, kilo voltage machines, deep therapy machines, Telecobalt machines, Medical linear accelerator. Basics of Teletherapy units, deep X-ray, Telecobalt units, Radiation protection, external beam characteristics, dose maximum and build up – bolus, percentage depth dose, tissue maximum ratio and tissue phantom ratio, Planned target Volume and Gross Tumour Volume.

(9 Lectures)

Unit 5

RADIATION AND RADIATION PROTECTION: Principles of radiation protection, protective materials-radiation effects, somatic, genetic stochastic and deterministic effect. Personal monitoring devices: TLD film badge, pocket dosimeter, OSL dosimeter. Radiation dosimeter. Natural radioactivity, Biological effects of radiation, Radiation monitors. Steps to reduce radiation to Patient, Staff and Public. Dose Limits for Occupational workers and Public. AERB: Existence and Purpose.

(5 Lectures)

Unit 6

PHYSICS OF DIAGNOSTIC AND THERAPEUTIC SYSTEMS-II

Diagnostic nuclear medicine: Radio pharmaceuticals for radioisotope imaging, Radioisotope imaging equipment, Single photon and positron emission tomography. Therapeutic nuclear medicine: Interaction between radiation and matter Dose and isodose in radiation treatment. Medical Instrumentation: Basic Ideas of Endoscope and Cautery, Sleep Apnea and Cpap Machines, Ventilator and its modes.

(5 Lectures)

Practical (60 Hours)
PHYSICS LAB: DSE-1A LAB: Medical Physics

Sessions on the construction and use of specific measurement instruments and experimental apparatuses used in the physics lab, including necessary precautions.

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. Application to the specific experiments done in the lab.

At least 05 experiments from the following:

1. Understanding the working of a manual Hg Blood Pressure monitor, Stethoscope and to measure the Blood Pressure.
2. Understanding the working of a manual optical eye-testing machine and to learn eye-testing procedure.
3. Correction of Myopia (short sightedness) using a combination of lenses on an optical bench/breadboard.
4. Correction of Hypermetropia/Hyperopia (long sightedness) using a combination of lenses on an optical bench/breadboard.
5. To learn working of Thermo luminescent dosimeter (TLD) badges and measure the background radiation.
6. Familiarization with Geiger-Muller (GM) Counter & to measure background radiation
7. Familiarization with Radiation meter and to measure background radiation.
8. Familiarization with the Use of a Vascular Doppler.

References for Theory

1. Medical Physics, J.R. Cameron and J.G.Skofronick, Wiley (1978)
2. Basic Radiological Physics Dr. K.Thayalan- Jayapee Brothers Medical Publishing Pvt. Ltd. New Delhi (2003)
3. Christensen's Physics of Diagnostic Radiology: Curry, Dowdey and Murry - Lippincot Williams and Wilkins (1990).
4. Physics of the human body, Irving P. Herman, Springer (2007).
5. Physics of Radiation Therapy: F M Khan - Williams and Wilkins, 3rd edition (2003).
6. The essential physics of Medical Imaging: Bushberg, Seibert, Leidholdt and Boone. Lippincot Williams and Wilkins, Second Edition (2002)

Additional Reading

1. The Physics of Radiology-H E Johns and Cunningham.
2. Physics of Radiation Therapy : F M Khan - Williams and Wilkins, 3rd edition (2003)
3. Handbook of Physics in Diagnostic Imaging: R.S. Livingstone: B.I. Publications Pvt Ltd.

DSE-1A: Applied Dynamics (42227536)
Credit: 06 (Theory-04, Practical-02)
Theory: 60 Hours
Practical: 60 Hours

Course Objective

This course introduces the main topics of low-dimensional nonlinear systems, with applications to a wide variety of disciplines, including physics, engineering, mathematics, chemistry, and biology. This course begins with the first order dynamical system and the idea of phase space, flows and trajectories and ends with the elementary fluid dynamics. Students will also appreciate the introduction to chaos and fractals.

Course Learning Outcomes

Upon successful course completion, a student will be able to:

- Demonstrate understanding of the concepts that underlay the study of dynamical systems.
- Understand fractals as self-similar structures.
- Learn various forms of dynamics and different routes to chaos.

- Understand basic Physics of fluids and its dynamics theoretically and experimentally and by computational simulations
- In the Lab course, students will be able to perform Simulations/Lab experiments on: coupled Oscillators, Simulation of Simple Population, Predator-Prey Dynamics, Simple genetic circuits, rate equations for some simple chemical reactions, Fractal Formation in Deterministic Fractals, Fluid Flow Models.

Unit 1

Introduction to Dynamical systems: Definition of a continuous first order dynamical system. The idea of phase space flows and trajectories. Simple mechanical systems as first order dynamical systems: simple and damped harmonic oscillator. Sketching flows and trajectories in phase space. Fixed points, attractors, stability of fixed points, basin of attraction, notion of qualitative analysis of dynamical systems.

Examples of dynamical systems –

Population models e.g. exponential growth and decay, logistic growth, predator-prey dynamics. Rate equations for chemical reactions e.g. auto catalysis, bio stability.

(22 Lectures)

Unit 2

Introduction to Chaos and Fractals: Chaos in nonlinear equations - Logistic map and Lorenz equations: Dynamics from time series. Parameter dependence- steady, periodic and chaotic states. Cobweb iteration. Fixed points. Defining chaos- aperiodic, bounded, deterministic and sensitive dependence on initial conditions. Period- Doubling route to chaos.

Self-similarity and fractal geometry: Fractals in nature – trees, coastlines, earthquakes, etc. Need for fractal dimension to describe self-similar structure. Deterministic fractal vs. self-similar fractal structure.

(18 Lectures)

Unit 3

Elementary Fluid Dynamics: Importance of fluids: Fluids in the pure sciences, fluids in technology. Study of fluids: Theoretical approach, experimental fluid dynamics, computational fluid dynamics. Basic physics of fluids: The continuum hypothesis-concept of fluid element or fluid parcel; Definition of a fluid- shear stress; Fluid properties- viscosity, thermal conductivity, mass diffusivity, other fluid properties and equation of state; Flow phenomena- flow dimensionality, steady and unsteady flows, uniform and non-uniform flows, viscous and inviscid flows, incompressible and compressible flows, laminar and turbulent flows, rotational and irrotational flows, separated and unseparated flows. Flow visualization - streamlines, path lines, Streaklines.

(20 Lectures)

PRACTICAL (60 Hours)
PHYSICS LAB: DSE-1A LAB: Applied Dynamics

Computing and visualizing trajectories using software such as Scilab, Maple, Octave, XPPAUT based on Applied Dynamics problems like:

At least 06 experiments from the following:

1. To determine the coupling coefficient of coupled pendulums.
2. To determine the coupling coefficient of coupled oscillators.
3. To determine the coupling and damping coefficient of damped coupled oscillator.
4. To study population models e.g. exponential growth and decay, logistic growth, species competition, predator- prey dynamics, simple genetic circuits.
5. To study rate equations for chemical reactions e.g. auto catalysis, biostability.
6. To study examples from game theory.
7. Computational visualization of trajectories in the Sinai Billiard.
8. Computational visualization of trajectories Electron motion in mesoscopic conductors as a chaotic billiard problem.
9. Computational visualization of fractal formations of Deterministic fractal.
10. Computational visualization of fractal formations of self-similar fractal.
11. Computational visualization of fractal formations of Fractals in nature – trees, coastlines, earthquakes.
12. Computational Flow visualization - streamlines, pathlines, Streaklines.

References for Theory

Essential Readings

1. Nonlinear Dynamics and Chaos, S. H. Strogatz, Levant Books, Kolkata, 2007.
2. Understanding Nonlinear Dynamics, Daniel Kaplan and Leon Glass, Springer.
3. Nonlinear Dynamics: Integrability, Chaos and Patterns, M. Lakshmanan and S. Rajasekar, Springer, 2003.
4. An Introduction to Fluid Dynamics, G. K. Batchelor, Cambridge University Press, 2002.
5. Fluid Mechanics, 2/e, L. D. Landau and E. M. Lifshitz, Pergamon Press, Oxford, 1987.

Reference for Laboratory work

1. Nonlinear Dynamics and Chaos, S. H. Strogatz, Levant Books, Kolkata, 2007.
2. Understanding Nonlinear Dynamics, Daniel Kaplan and Leon Glass, Springer.
3. An Introduction to Fluid Dynamics, G. K. Batchelor, Cambridge University Press, 2002.
4. Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific and Engineering Applications: A. Vande Wouwer, P. Saucez, C. V. Fernández, 2014, Springer.

DSE: 2A: Solid State Physics (42227637)
Credit: 06 (Theory-04, Practical-02)
Theory: 60 Hours
Practical: 60 Hours

Course Objective

This course introduces the basic concepts and principles required to understand the various properties exhibited by condensed matter, especially solids. It enables the students to appreciate how the interesting and wonderful properties exhibited by matter depend upon its atomic and molecular constituents. The gained knowledge helps to solve problems in solid state physics using relevant mathematical tools. It also communicates the importance of solid state physics in modern society.

Course Learning Outcomes

On successful completion of the module students should be able to

- Elucidate the concept of lattice, crystals and symmetry operations.
- Understand the elementary lattice dynamics and its influence on the properties of materials.
- Describe the main features of the physics of electrons in solids: origin of energy bands, and their influence electronic behavior.
- Explain the origin of dia-, para-, and ferro-magnetic properties of solids.
- Explain the origin of the dielectric properties exhibited by solids and the concept of polarizability.
- Learn the properties of superconductivity in solid.
- In the laboratory students will carry out experiments based on the theory that they have learned to measure the magnetic susceptibility, dielectric constant, trace hysteresis loop. They will also employ to four probe methods to measure electrical conductivity and the hall set up to determine the hall coefficient of a semiconductor.

Unit 1

Crystal Structure: Solids: Amorphous and Crystalline Materials. Lattice Translation Vectors. Lattice with a Basis. Unit Cell. Types of lattices. Miller Indices. Reciprocal Lattice. Brillouin Zones. Diffraction of X-rays by Crystals. Bragg's Law.

(12 Lectures)

Unit 2

Elementary Lattice Dynamics : Lattice Vibrations and Phonons : Linear Monoatomic and Diatomic Chains. Acoustical and Optical Phonons. Qualitative Description of the Phonon Spectrum in Solids. Dulong and Petit's Law, Einstein and Debye theories of specific heat of solids (qualitative only). T^3 law.

(10 Lectures)

Unit 3

Free electron theory: Electrons in metals- Drude Model (Basic concept), Elementary band theory: Kronig Penney model. Band Gap. Classification of solids based on band gap into conductors, semiconductors and insulators. P-and N- type Semiconductors. Conductivity of Semiconductors, mobility, Hall effect in metal and Semiconductor. Hall coefficient. Application of Hall effect.

(10 Lectures)

Unit 4

Magnetic Properties of Matter : Dia-, Para-, Ferri- and Ferro- magnetic Materials. Classical Langevin Theory of dia– and Para- magnetism.Weiss's Theory of Ferromagnetism and Ferromagnetic Domains.Curie's law, B-H Curve.Hysteresis and Energy Loss.

(12 Lectures)

Unit 5

Dielectric Properties of Materials: Polarization. Local Electric Field in solids. Depolarization Field. Electric Susceptibility. Polarizability. Clausius Mossoti Equation. Classical Theory of Electric Polarizability. Normal and Anomalous Dispersion.

(11 Lectures)

Unit 6

Superconductivity: Experimental Results. Critical Temperature. Critical magnetic field. Meissner effect. Type I and II Superconductors.

(5 Lectures)

Practical (60 Hours)
PHYSICS LAB: DSE-2A LAB: Solid State Physics

Sessions on the construction and use of specific measurement instruments and experimental apparatuses used in the solid state physics lab, including necessary precautions.

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. Application to the specific experiments done in the lab.

At least 06 experiments from the following

1. Measurement of 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 study the dielectric response of materials with frequency
5. To determine the complex dielectric constant and plasma frequency of a metal using Surface Plasmon Resonance (SPR) technique.
6. To determine the refractive index of a dielectric layer using SPR technique.
7. To study the PE Hysteresis loop of a Ferroelectric Crystal.

8. To draw the BH curve of iron (Fe) using a Solenoid and determine the energy loss from Hysteresis loop.
9. To measure the resistivity of a semiconductor (Ge) crystal with temperature (up to 150o C) by four-probe method and determine its band gap.
10. To determine the Hall coefficient of a semiconductor sample.
11. Analysis of X-Ray diffraction data in terms of unit cell parameters and estimation of particle size.
12. Measurement of change in resistance of a semiconductor with magnetic field.

References for Theory

Essential Readings

1. Introduction to Solid State Physics, Charles Kittel, 8th Ed., 2004, Wiley India Pvt.Ltd.
2. Elements of Solid-State Physics, J.P. Srivastava, 2nd Ed., 2006, Prentice-Hall of India
3. Introduction to Solids, Leonid V. Azaroff, 2004, Tata Mc-Graw Hill.
4. Solid State Physics, Neil W. Ashcroft and N. David Mermin, 1976, Cengage Learning.
5. Elementary Solid State Physics, M.Ali Omar, 2006, Pearson.

Additional Readings

1. Solid State Physics, Rita John, 2014, McGraw Hill.
2. Solid State Physics, M.A. Wahab, 2011, Narosa Publications

Reference for Laboratory work

1. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
2. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers.
3. Elements of Solid-State Physics, J.P. Srivastava, 2nd Ed., 2006, Prentice-Hall of India.
4. An Advanced Course in Practical Physics, D. Chattopadhyay & P. C. Rakshit, 2013, New Book Agency (P) Ltd.
5. Practical Physics, G.L. Squires, 2015, 4th Edition, Cambridge University Press

DSE-2A: Embedded System: Introduction to microcontroller (42227638)
Credit: 06 (Theory-04, Practical-02)
Theory: 60 Hours
Practical: 60 Hours

Course Objective

This course familiarizes students to the designing and development of embedded systems. This course gives a review of microprocessor and introduces microcontroller 8051.

Course Learning Outcomes

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

- Know the major components that constitute an embedded system.
- Understand what is a microcontroller, microcomputer embedded system.
- Describe the architecture of 8051 microcontroller.
- Write simple programs for 8051 microcontrollers in C language.
- Understand key concepts of 8051 microcontroller systems like I/O operations, interrupts, programming of timers and counters.
- Interface 8051 microcontroller with peripherals
- Understand and explain concepts and architecture of embedded systems
- Implement small programs to solve well-defined problems on an embedded platform.
- Develop familiarity with tools used to develop an embedded environment
- Learn to use the Arduino Uno (an open source microcontroller board) in simple applications.
- In the laboratory, students will program 8051 microcontroller and Arduino to perform various experiments.

Unit 1

Embedded system introduction: Introduction to embedded systems and general-purpose computer systems, architecture of embedded system, classifications, applications and purpose of embedded systems, challenges and design issues in embedded system, operational & non-operational quality attributes of embedded system, elemental description of embedded processors and microcontrollers.

(6 Lectures)

Review of microprocessors: Organization of Microprocessor based system, 8085μp pin diagram and architecture, Data bus and address bus, 8085 programming model, instruction classification, subroutines, stacks and its implementation, delay subroutines, hardware and software interrupts.

(4 Lectures)

Unit 2

8051 microcontroller: Introduction and block diagram of 8051 microcontroller, architecture of 8051, overview of 8051 family, 8051 assembly language programming, Program Counter and ROM memory map, Data types and directives, Flag bits and Program Status Word (PSW) register, Jump, loop and call instructions.

(12 Lectures)

8051 I/O port programming: Introduction of I/O port programming, pin out diagram of 8051 microcontroller, I/O port pins description & their functions, I/O port programming in 8051 (using Assembly Language), I/O programming: Bit manipulation.

(4 Lectures)

Unit 3

Programming of 8051: 8051 addressing modes and accessing memory using various addressing modes, assembly language instructions using each addressing mode, arithmetic and logic instructions, 8051 programming: for time delay and I/O operations and manipulation, for arithmetic and logic operations, for ASCII and BCD conversions.

(12 Lectures)

Timer and counter programming: Programming 8051 timers, counter programming.

(3 Lectures)

Unit 4

Serial port programming with and without interrupt: Introduction to 8051 interrupts, programming timer interrupts, programming external hardware interrupts and serial communication interrupt, interrupt priority in the 8051.

(6 Lectures)

Interfacing 8051 microcontroller to peripherals: Parallel and serial ADC, DAC interfacing, LCD interfacing.

(2 Lectures)

Unit 5

Programming Embedded Systems: Structure of embedded program, infinite loop, compiling, linking and locating, downloading and debugging.

(3 Lectures)

Embedded system design and development: Embedded system development environment, file types generated after cross compilation, disassembler/decompiler, simulator, emulator and debugging, embedded product development lifecycle, trends in embedded industry.

(8 Lectures)

Practical (60 Hours)
PRACTICALS- DSE-2A LAB: Embedded System: Introduction to Microcontroller

Sessions on the use of specific equipment and experimental apparatuses used in the physics lab, including necessary precautions.

Sessions on the review of experimental data analysis, error analysis and reporting and their application to the specific experiments done in the lab.

Following experiments (At least 06 using 8051):

1. To find that the given numbers is prime or not.
2. To find the factorial of a number.
3. Write a program to make the two numbers equal by increasing the smallest number and decreasing the largest number.
4. Use one of the four ports of 8051 for O/P interfaced to eight LED's. Simulate binary counter (8 bit) on LED's.
5. Program to glow first four LED then next four using TIMER application.
6. Program to rotate the contents of the accumulator first right and then left.
7. Program to run a countdown from 9-0 in the seven segment LED display.
8. To interface seven segment LED display with 8051 microcontrollers and display 'HELP' in the seven segment LED display.
9. To toggle '1234' as '1324' in the seven segment LED.
10. Interface stepper motor with 8051 and write a program to move the motor through a given angle in clock wise or counter clockwise direction.
11. Application of embedded systems: Temperature measurement, some information on LCD display, interfacing a keyboard.

References for Theory

Essential Readings

1. Embedded Systems: Architecture, Programming & Design, Raj Kamal, 2008, Tata McGraw Hill.
2. The 8051 Microcontroller and Embedded Systems Using Assembly and C, M.A.Mazidi, J.G. Mazidi and R.D. McKinlay, 2nd Edition, 2007, Pearson Education.
3. Embedded Systems and Robots, Subrata Ghoshal, 2009, Cengage Learning.
4. Introduction to embedded system, K.V. Shibu, 1st Edition, 2009, McGraw Hill.
5. Microprocessors and Microcontrollers, Krishna Kant, 2nd Edition, 2016. PHI learning Pvt. Ltd.

References for Laboratory

1. Embedded System, B.K. Rao, 2011, PHI Learning Pvt. Ltd.

2. Embedded Microcomputer systems: Real time interfacing, J. W. Valvano 2011, Cengage Learning.

DSE-2A: Nuclear and Particle Physics (42227639)
Credit: 06 (Theory-05, Tutorial-01)
Theory: 75 Hours
Tutorial: 15 Hours

Course Objective

The objective of the course is to impart the understanding of the sub atomic particles and their properties. It will emphasize to gain knowledge about the different nuclear techniques and their applications in different branches Physics and societal application. The course will focus on the developments of problem based skills.

Course Learning Outcomes

- To be able to understand the basic properties of nuclei as well as knowledge of experimental determination of the same, the concept of binding energy, its various dependent parameters, N-Z curves and their significance
- To appreciate the formulations and contrasts between different nuclear models such as Liquid drop model, Fermi gas model and Shell Model and evidences in support.
- Knowledge of radioactivity and decay laws. A detailed analysis, comparison and energy kinematics of alpha, beta and gamma decays.
- Familiarization with different types of nuclear reactions, Q- values, compound and direct reactions.
- To know about energy losses due to ionizing radiations, energy losses of electrons, gamma ray interactions through matter and neutron interaction with matter. Through the section on accelerators students will acquire knowledge about Accelerator facilities in

India along with a comparative study of a range of detectors and accelerators which are building blocks of modern day science.

- It will acquaint students with the nature and magnitude of different forces, particle interactions, families of sub- atomic particles with the different conservation laws, concept of quark model.
- The acquired knowledge can be applied in the areas of nuclear medicine, medical physics, archaeology, geology and other interdisciplinary fields of Physics and Chemistry. It will enhance the special skills required for these fields.

Unit 1

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

(10 Lectures)

Unit 2

Nuclear Models: Liquid drop model approach, semi empirical mass formula and significance of its various terms, condition of nuclear stability, nucleon separation energies (up to two nucleons), Fermi gas model (degenerate fermion gas, nuclear symmetry potential in Fermi gas), evidence for nuclear shell structure and the basic assumptions of shell model.

(11 Lectures)

Unit 3

Radioactivity decay: Decay rate and equilibrium (Secular and Transient) (a) Alpha decay: basics of α-decay processes, theory of α-emission, Gamow factor, Geiger Nuttall law, α-decay spectroscopy, decay Chains. (b) β- decay: energy kinematics for β-decay, β-spectrum, positron emission, electron capture, neutrino hypothesis. (c) Gamma decay: Gamma rays emission from the excited state of the nucleus & kinematics, internal conversion.

(10 Lectures)

Unit 4

Nuclear Reactions: Types of Reactions, units of related physical quantities, Conservation Laws, kinematics of reactions, Q-value, reaction rate, reaction cross section, Concept of compound and direct reaction, resonance reaction, Coulomb scattering (Rutherford scattering).

(8 Lectures)

Unit 5

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

(9 Lectures)

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

(9 Lectures)

Particle Accelerators: Accelerator facility available in India: Van-de Graaff generator (Tandem accelerator), Linear accelerator, Cyclotron, Synchrotrons (Principal, construction, working, advantages and disadvantages).

(7 Lectures)

Unit 6

Particle physics: Particle interactions (concept of different types of forces), basic features, Cosmic Rays, types of particles and its families, Conservation Laws (energy and momentum, angular momentum, parity, baryon number, Lepton number, Isospin, Strangeness) concept of quark model, color quantum number and gluons.

(11 Lectures)

References for Theory

Essential Readings

1. Basic ideas and concepts in Nuclear Physics: An introductory approach by K Heyde, third edition, IOP Publication, 1999.
2. Nuclear Physics by S N Ghoshal, First edition, S. Chand Publication, 2010.
3. Introductory Nuclear Physics by K S Krane, Wiley-India Publication, 2008.
4. Radiation detection and measurement, G F Knoll, John Wiley & Sons, 2010.
5. Introduction to elementary particles by D J Griffiths, Wiley, 2008.

Additional Readings

1. Concepts of Nuclear Physics by B L Cohen, Tata McGraw Hill Publication, 1974.
2. Physics and Engineering of Radiation Detection by S N Ahmed, Academic Press Elsevier, 2007.
3. Techniques for Nuclear and Particle Physics experiments by WR Leo, Springer, 1994.
4. Modern Physics by R A Serway, C J Moses and C A Moyer, 3rd edition, Thomson Brooks Cole, 2012.
5. Modern Physics for Scientists and Engineers by S T Thornton and A Rex, 4th edition, Cengage Learning, 2013
6. Concepts of Modern Physics by Arthur Beiser, McGraw Hill Education, 2009.
7. Nuclear Physics: principles and applications by J Lilley, Wiley Publication, 2006.

References for Tutorial

1. Schaum's Outline of Modern Physics, McGraw-Hill, 1999.

2. Schaum's Outline of College Physics, by E. Hecht, 11th edition, McGraw Hill, 2009.
3. Modern Physics by K Sivaprasath and R Murugeshan, S Chand Publication, 2010.
4. Nuclear Physics "Problem-based Approach" Including MATLAB by Hari M. Aggarwal, PHI Learning Pvt. Ltd. (2016).

DSE-2A: Quantum Mechanics (42227640)
Credit: 06 (Theory-04, Practical-02)
Theory: 60 Hours
Practical: 60 Hours

Course Objective

After learning the elements of modern physics, in this course students would be exposed to more advanced concepts in quantum physics and their applications to problems of the sub atomic world.

Course Learning Outcomes

The Students will be able to learn the following from this course:

- Methods to solve time-dependent and time-independent Schrodinger equation.
- Quantum mechanics of simple harmonic oscillator.
- Non-relativistic hydrogen atom: spectrum and Eigen functions.
- Angular momentum: Orbital angular momentum and spin angular momentum.
- Bosons and fermions - symmetric and anti-symmetric wave functions.
- Application to atomic systems
- In the laboratory course, with the exposure in computational programming in the computer lab, the student will be in a position to solve Schrodinger equation for ground state energy and wave functions of various simple quantum mechanical one-dimensional and three dimensional potentials.

Unit 1

Time dependent Schrodinger equation: Time dependent Schrodinger equation and dynamical evolution of a quantum state; Properties of Wave Function. Interpretation of Wave

Function Probability and probability current densities in three dimensions; Conditions for Physical Acceptability of Wave Functions. Normalization. Linearity and Superposition Principles. Eigenvalues and eigen functions. Position, momentum & Energy operators; commutator of position and momentum operators; Expectation values of position & momentum. Wave Function of a Free Particle.

(10 Lectures)

Unit 2

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

(12 Lectures)

Unit 3

General discussion of bound states in an arbitrary potential: Continuity of a wave function, boundary condition and emergence of discrete energy levels; application to one-dimensional problem- square well potential; Quantum mechanics of simple harmonic oscillator-energy levels and energy eigen functions using Frobenius method.

(10 Lectures)

Unit 4

Quantum theory of hydrogen-like atoms: time independent Schrodinger equation in spherical polar coordinates; separation of variables for the second order partial differential equation; angular momentum operator and quantum numbers; Radial wave functions from Frobenius method; Orbital angular momentum quantum numbers l and m; s, p, d, shells (basic ideas only).

(10 Lectures)

Unit 5

Atoms in Electric and Magnetic Fields: Electron Angular Momentum. Angular momentum Quantization. Electron Spin and Spin Angular Momentum. Larmor's Theorem. Spin Magnetic Moment. Stern-Gerlach Experiment. Normal Zeeman Effect: Electron Magnetic Moment and Magnetic Energy.

(8 Lectures)

Unit 6

Many-electron atoms: Pauli's Exclusion Principle. Symmetric and Anti-symmetric Wave Functions. Spin orbit coupling. Spectral Notations for Atomic States. Total Angular Momentum. Spin-orbit coupling in atoms: L-S and J-J couplings.

(10 Lectures)

PRACTICAL (60 Hours)
PRACTICALS- DSE-2A LAB: Quantum Mechanics

Use C/C ++ /Scilab for solving the following problems based on Quantum Mechanics like:

1. Solve the s-wave Schrodinger equation for the ground state and the first excited state of the hydrogen atom:

$$\frac{d^2y}{dr^2} = A(r)u(r), A(r) = \frac{2m}{\hbar^2}[V(r) - E] where V(r) = \frac{-e^2}{r}$$

where m is the reduced mass of the electron. 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 $(eVÅ)^{1/2}$, ħc = 1973 (eVÅ) and m = 0.511×10^6 eV/c^2.

2. Solve the s-wave radial Schrodinger equation for an atom:

$$\frac{d^2y}{dr^2} = A(r)u(r), A(r) = \frac{2m}{\hbar^2}[V(r) - E]$$

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

$$V(r) = \frac{-e^2}{r} e^{-r/a}$$

Find the energy (in eV) of the ground state of the atom to an accuracy of three significant digits. Also, plot the corresponding wave function. Take e = 3.795 $(eVÅ)^{1/2}$, m = 0.511×10^6 eV/c^2, and a = 3 Å, 5 Å, 7 Å. In these units ħc = 1973 (eVÅ). 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:

$$\frac{d^2y}{dr^2} = A(r)u(r), A(r) = \frac{2m}{\hbar^2}[V(r) - E]$$

For the an harmonic oscillator potential

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

for the ground state energy (in MeV) of particle to an accuracy of three significant digits. Also, plot the corresponding wave function. Choose m = 940 MeV/c^2, k = 100 MeV fm^{-2}, b = 0, 10, 30 MeV fm^{-3}. In these units, cħ = 197.3 MeV fm. The ground state energy is expected 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:

$$\frac{d^2y}{dr^2} = A(r)u(r), A(r) = \frac{2\mu}{\hbar^2}[V(r) - E]$$

Where μ is the reduced mass of the two-atom system for the Morse potential

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

Find the lowest vibrational energy (in MeV) of the molecule to an accuracy of three significant digits. Also plot the corresponding wave function.

Take: m = 940×10^6 eV/c^2, D = 0.755501 eV, α = 1.44, r_0 = 0.131349 Å

Laboratory based experiments (Optional):

5. Study of Electron spin resonance- determine magnetic field as a function of the resonance frequency.
6. Study of Zeeman effect: with external magnetic field; Hyperfine splitting.
7. Quantum efficiency of CCDs.

References for Theory

Essential Readings

1. Quantum Mechanics, B. H. Bransden and C. J. Joachain; 2nd Ed., Prentice Hall, 2000.
2. A Text book of Quantum Mechanics, P.M. Mathews and K. Venkatesan, 2nd Ed.,2010, McGraw Hill.
3. Quantum Mechanics for Scientists & Engineers, D.A.B. Miller, 2008, Cambridge University Press.
4. Quantum Mechanics: Theory and Applications, (2019), (Extensively revised 6th Edition), Ajoy Ghatak and S. Lokanathan, Laxmi Publications, New Delhi.
5. Introduction to Quantum Mechanics, D.J. Griffith, 2nd Ed. 2005, Pearson Education.

Additional Readings

1. Introduction to Quantum Mechanics, R. H. Dicke and J. P. Wittke, Addison-Wesley Publications, 1966.
2. Quantum Mechanics, Leonard I. Schiff, 3rd Edn. 2010, Tata McGraw Hill.
3. Quantum Mechanics, Robert Eisberg and Robert Resnick, 2ndEdn., 2002, Wiley.
4. Quantum Mechanics, Bruce Cameron Reed, 2008, Jones and Bartlett Learning.
5. Quantum Mechanics, Walter Greiner, 4th Edn., 2001, Springer.
6. Introductory Quantum Mechanics, R. L. Liboff; 4th Ed., Addison Wesley, 2003.
7. Quantum Mechanics: Concepts and Applications, 2nd Edition,Nouredine Zettili, A John Wiley and Sons, Ltd., Publication

Reference for Laboratory work

1. Schaum's Outline of Programming with C++. J.Hubbard, 2000, McGraw- Hill Pub.
2. Numerical Recipes in C: The Art of Scientific Computing, W.H. Press et.al., 3rd Edn., 2007, Cambridge University Press.
3. A Guide to MATLAB, B.R. Hunt, R.L. Lipsman, J.M. Rosenberg, 2014, 3rd Edn., Cambridge University Press
4. Elementary Numerical Analysis, K.E. Atkinson, 3rd E d . 2 0 0 7 ,Wiley India Edition.
5. Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific & Engineering Applications: A.V. Wouwer, P. Saucez, C.V. Fernández.2014 Springer.

DSE-2A: Digital Signal processing (42227641)
Credit: 06 (Theory-04, Practical-02)
Theory: 60 Hours
Practical: 60 Hours

Course Objective

The prime goal of this paper is to develop a thorough understanding of the central elements of discrete time signal processing theory and correlate this theory with the real-world signal processing applications.

Course Learning Outcomes

At the end of this course, students will be able to

- Learn basic discrete-time signal and system types, convolution sum, impulse and frequency response concepts for linear time-invariant (LTI) systems.
- Understand use of different transforms and analyze the discrete time signals and systems.
- Realize the use of LTI filters for filtering different real world signals. The concept of transfer
- Learn to solve Difference Equations.
- Develop an ability to analyze DSP systems like linear-phase, FIR, IIR, All-pass, averaging and notch Filter etc.
- Understand the discrete Fourier transform (DFT) and realize its implementation using FFT techniques.
- Design and understand different types of digital filters such as finite & infinite impulse response filters for various applications.
- In the Lab course, the students will realize various concepts using Scilab simulations like Digital Filters and their classifications based on the response, design and algorithm, Fluency in using Fast Fourier Transform, Signal generation, realization of systems and finding their transfer function, characterization using pole-zero plots and designing digital filters.

Unit 1

Discrete-Time Signals and Systems: Classification of Signals, Transformations of the Independent Variable, Periodic and Aperiodic Signals, Energy and Power Signals, Even and Odd Signals, Discrete-Time Systems, System Properties. Impulse Response, Convolution Sum; Graphical Method; Analytical Method, Properties of Convolution; Commutative; Associative; Distributive; Shift; Sum Property System Response to Periodic Inputs, Relationship Between LTI System Properties and the Impulse Response; Causality; Stability; Invertibility, Unit Step Response.

(10 Lectures)

Unit 2

Discrete-Time Fourier Transform: Fourier Transform Representation of Aperiodic Discrete-Time Signals, Periodicity of DTFT, Properties; Linearity; Time Shifting; Frequency Shifting; Differencing in Time Domain; Differentiation in Frequency Domain; Convolution Property. The z-Transform: Bilateral (Two-Sided) z-Transform, Inverse z- Transform, Relationship Between z-Transform and Discrete-Time Fourier Transform, z-plane, Region-of- Convergence; Properties of ROC, Properties; Time Reversal; Differentiation in the z-Domain; Power Series Expansion Method (or Long Division Method); Analysis and Characterization of LTI Systems; Transfer Function and Difference-Equation System. Solving Difference Equations.

(15 Lectures)

Unit 3

Filter Concepts: Phase Delay and Group delay, Zero-Phase Filter, Linear-Phase Filter, Simple FIR Digital Filters, Simple IIR Digital Filters, All pass Filters, Averaging Filters, Notch Filters.

(5 Lectures)

Discrete Fourier Transform: Frequency Domain Sampling (Sampling of DTFT), The Discrete Fourier Transform (DFT) and its Inverse, DFT as a Linear transformation, Properties; Periodicity; Linearity; Circular Time Shifting; Circular Frequency Shifting; Circular Time Reversal; Multiplication Property; Parseval's Relation, Linear Convolution Using the DFT (Linear Convolution Using Circular Convolution), Circular Convolution as Linear Convolution with aliasing.

(10 Lectures)

Unit 4

Fast Fourier Transform: Direct Computation of the DFT, Symmetry and Periodicity Properties of the Twiddle factor (WN), Radix-2 FFT Algorithms; Decimation-In-Time (DIT) FFT Algorithm; Decimation-In-Frequency (DIF) FFT Algorithm, Inverse DFT Using FFT Algorithms.

(5 Lectures)

Unit 5

Realization of Digital Filters: Non-Recursive and Recursive Structures, Canonic and Non Canonic Structures, Equivalent Structures (Transposed Structure), FIR Filter structures; Direct-Form; Cascade-Form; Basic structures for IIR systems; Direct-Form I.

Finite Impulse Response Digital Filter: Advantages and Disadvantages of Digital Filters, Types of Digital Filters: FIR and IIR Filters; Difference Between FIR and IIR Filters, Desirability of Linear-Phase Filters, Frequency Response of Linear-Phase FIR Filters, Impulse Responses of Ideal Filters, Windowing Method; Rectangular; Triangular; Kaiser Window, FIR Digital Differentiators.

Infinite Impulse Response Digital Filter: Design of IIR Filters from Analog Filters, IIR Filter Design by Approximation of Derivatives, Backward Difference Algorithm, Impulse Invariance Method.

(15 Lectures)

PRACTICAL (60 Hours)
PRACTICAL-DSE-2A LAB: Digital Signal Processing

At least 06 experiments from the following using Scilab/Matlab.

Introduction to Numerical computation software Scilab/Matlab be introduced in the lab.

1. Write a program to generate and plot the following sequences: (a) Unit sample sequence $\delta(n)$, (b) unit step sequence $u(n)$, (c) ramp sequence $r(n)$, (d) real valued exponential sequence $x(n) = (0.8)^n u(n)$ for $0 \le n \le 50$.
2. Write a program to compute the convolution sum of a rectangle signal (or gate function) $x(n) = rect\left(\frac{n}{2N}\right) = \Pi\left(\frac{n}{2N}\right) = \begin{cases} 1 & -N \le n \le N \\ 0 & otherwise \end{cases}$ with itself for N = 5
3. An LTI system is specified by the difference equation $y(n) = 0.8y(n-1) + x(n)$

   (a) Determine $H(e^{jw})$

   (b) Calculate and plot the steady state response $y_{ss}(n)$ to

   $$x(n) = \cos(0.5\pi n)u(n)$$

4. Given a casual system $y(n) = 0.9y(n-1) + x(n)$

   (a) Find $H(z)$ and sketch its pole-zero plot

   (b) Plot the frequency response $\left|H(e^{jw})\right|$ and $\angle H(e^{jw})$

5. Design a digital filter to eliminate the lower frequency sinusoid of $x(t) = \sin 7t + \sin 200t$. The sampling frequency is $f_s = 500\ Hz$. Plot its pole zero diagram, magnitude response, input and output of the filter.
6. Let $x(n)$ be a 4-point sequence:

   $$x(n) = \underset{\uparrow}{\{1,1,1,1\}} = \begin{cases} 1 & 0 \le n \le 3 \\ 0 & otherwise \end{cases}$$

   Compute the DTFT $X(e^{jw})$ and plot its magnitude

   (a) Compute and plot the 4 point DFT of $x(n)$

   (b) Compute and plot the 8 point DFT of $x(n)$ (by appending 4 zeros)

   (c) Compute and plot the 16 point DFT of $x(n)$ (by appending 12 zeros

7. Let $x(n)$ and $h(n)$ be the two 4-point sequences, $x(n) = \underset{\uparrow}{\{1,2,2,1\}}$

   $$h(n) = \underset{\uparrow}{\{1,-1,-1,1\}}$$

   Write a program to compute their linear convolution using circular convolution.

8. Using a rectangular window, design a FIR low-pass filter with a pass-band gain of unity, cut off frequency of 1000 Hz and working at a sampling frequency of 5 KHz. Take the length of the impulse response as 17.

9. Design an FIR filter to meet the following specifications:

   Passband edge $F_p = 2\ KHz$
   Stopband edge $F_s = 5\ KHz$
   Passband attenuation $A_p = 2\ dB$
   Stopband attenuation $A_s = 42\ dB$
   Sampling frequency $F_s = 20\ KHz$

10. The frequency response of a linear phase digital differentiator is given by

$$H_d(e^{jw}) = jwe^{-j\tau w} |w| \leq \pi$$

Using a Hamming window of length M = 21, design a digital FIR differentiator. Plot the amplitude response.

References for Theory

Essential Readings

1. Digital Signal Processing, Tarun Kumar Rawat, 2015, Oxford University Press, India
2. Digital Signal Processing, S. K. Mitra, McGraw Hill, India.
3. Principles of Signal Processing and Linear Systems, B.P. Lathi, 2009, 1st Edn. Oxford University Press.
4. Fundamentals of signals and systems, P.D. Cha and J.I. Molinder, 2007, Cambridge University Press.
5. Digital Signal Processing Principles Algorithm & Applications, J.G. Proakis and D.G. Manolakis, 2007, 4th Edn., Prentice Hall.

Additional Readings

1. Digital Signal Processing, A. Anand Kumar, 2nd Edition, 2016, PHI learning Private Limited.
2. Digital Signal Processing, Paulo S.R. Diniz, Eduardo A.B. da Silva, Sergio L .Netto, 2nd Edition, 2017, Cambridge University Press.

Reference for Laboratory work

1. A Guide to MATLAB, B.R. Hunt, R.L. Lipsman, J.M. Rosenberg, 2014, 3rd Edn., Cambridge University Press.
2. Fundamentals of Digital Signal processing using MATLAB, R.J. Schilling and S.L. Harris, 2005, Cengage Learning.
3. Getting started with MATLAB, Rudra Pratap, 2010, Oxford University Press.

DSE-2A: Astronomy and Astrophysics (42227642)
Credit: 06 (Theory-05, Tutorial-01)
Theory: 75 Hours
Tutorial: 15 Hours

Course Objective

This course is meant to introduce undergraduate students to the wonders of the Universe. Students will understand how astronomers over millennia have come to understand mysteries of the universe using laws of geometry and physics, and more recently chemistry and biology. They will learn about diverse set of astronomical and astrophysical phenomenon, from the daily and yearly motion of stars and planets in the night sky which they can observe themselves, to the expansion of the universe deduced from the latest observations and cosmological models. The course presupposes school level understanding of mathematics and physics.

Course Learning Outcomes

Students completing this course will gain an understanding of

- Different types of telescopes, diurnal and yearly motion of astronomical objects, and astronomical coordinate systems and their transformations.
- Brightness scale for stars, types of stars, their structure and evolution on HR diagram.
- Components of Solar System and its evolution
- The large scale structure of the Universe and its history
- Distribution of chemical compounds in the interstellar medium and astrophysical conditions necessary for the emergence and existence of life.

Unit 1

Introduction to Astronomy and Astronomical Scales: Overview of the Night Sky, Diurnal and Yearly motions of the Sun, Stars and Constellations. Size, Mass, Density and Temperature of Astronomical objects, Basic concepts of Positional Astronomy: Celestial Sphere, Geometry of a Sphere, Spherical Triangle, Astronomical Coordinate Systems, Horizon System, Equatorial System, Conversion of Coordinates. Rising and Setting Times, Measurement of Time, Sidereal Time, Apparent Solar Time, Mean Solar Time, Equation of Time, Astronomical Time Systems (LMT, UT, UTC).

(16 Lectures)

Unit 2

Basic Parameters of Stars: Determination of Distance by Parallax Method, Proper Motion, Brightness, Radiant Flux and Luminosity, Apparent and Absolute magnitude scale, Distance Modulus; Extinction, Determination of Temperature and Radius of a star; Stellar Spectra, Atomic Spectra Revisited, Spectral Types and their Temperature Dependence, Black Body

Approximation, Luminosity Classification, H R Diagram, and Relations between Stellar Parameters.

(15 Lectures)

Unit 3

Observational Tools and Physical Principles : 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 and Radio telescopes, Current Indian Observatories. Virial theorem for N particle systems, applications in Astrophysics. Equations for Hydrostatic and Thermal Equilibria, Mean Molecular Weight of Stellar Gas, Stellar Energy Sources.

(15 Lectures)

Unit 4

Sun, the Milky Way and Astrochemistry: Solar Parameters, Sun's Internal Structure, Solar Photosphere, Solar Atmosphere, Chromosphere. Corona, Solar Activity. Basic Structure and Properties of the Milky Way, Nature of rotation of the Milky Way (Differential rotation of the Galaxy and Oort Constants, Rotation Curve of the Galaxy and the Dark Matter, Nature of the Spiral Arms), Properties of and around the Galactic Nucleus. Molecular Spectroscopy, Interstellar molecules, Organic compounds in Interstellar Medium and Solar system.

(15 Lectures)

Unit 5

Cosmology and Astrobiology: Cosmology: Standard Candles (Cepheids and SNe Type1a), Cosmic Distance Ladder. Olbers Paradox, Hubble Expansion, Cosmological Principle, Newtonian Cosmology and Friedmann Models. Chemistry of Life, Origin of Life, Chances of Life in the Solar System, Exoplanets.

(14 Lectures)

References for Theory

Essential Readings

1. Fundamental of Astronomy (Fourth Edition), H. Karttunen et al. Springer
2. Astrophysics Stars and Galaxies K D Abhyankar, Universities Press
3. ModernAstrophysics, B.W. Carroll & D.A. Ostlie, Addison-Wesley Publishing Co.
4. Introductory Astronomy and Astrophysics, M. Zeilik and S.A. Gregory, 4th Edition, Saunders College Publishing.
5. The Molecular Universe, A.G.G.M. Tielens (Sections I, II and III), Reviews of Modern Physics, Vol 85, July September, 2013

Additional Readings

1. Explorations: Introduction to Astronomy, Thomos Arny and Stephen Schneider, 2014, 7th edition, McGraw Hill
2.. Textbook of Astronomy and Astrophysics with elements of cosmology, V.B. Bhatia, Narosa Publication.
3. Baidyanath Basu, An introduction to Astrophysics, Second printing, Prentice - Hall of India Private limited, New Delhi,2001.
4. The Physical Universe: An Introduction to Astronomy, F H Shu, University Science Books

DSE-2A: Atmospheric Physics (42227643)

Credit: 06 (Theory-04, Practical-02)

Theory: 60 Hours

Practical: 60 Hours

Course Objective

This paper aims to describe the characteristics of the Earth's atmospheric thermal structure and chemical composition. It enables to learn remote sensing techniques to explore atmospheric processes and helps to understand long term oscillations and fluid system dynamics which control climate change. Also, it delineates characteristics of pollutants and aerosols variability in the lower and middle atmosphere.

Course Learning Outcomes

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

- Learn and understand structure of temperature profiles and fine scale features in the troposphere using observations.
- Understand Atmospheric waves: surface water waves, atmospheric gravity waves, acoustic waves etc.
- Learn remote sensing techniques such as radar, LIDAR, and satellite to explore atmospheric processes.
- Understand properties of aerosols, their radiative and health effects.

Unit 1

General features of Earth's atmosphere: Thermal structure of the Earth's Atmosphere, Composition of atmosphere, Hydrostatic equation, Potential temperature, Atmospheric Thermodynamics, Greenhouse effect, Local winds, monsoons, fogs, clouds, precipitation, Atmospheric boundary layer, Sea breeze and land breeze. Instruments for meteorological observations including RS/RW, meteorological processes and convective systems, fronts, Cyclones and anticyclones, thunderstorms.

(12 Lectures)

Unit 2

Atmospheric Dynamics: Scale analysis, Fundamental forces, Basic conservation laws, The Vectorial form of the momentum equation in rotating coordinate system, scale analysis of equation of motion, Applications of the basic equations, Circulations and vorticity, Atmospheric oscillations, Quasi biennial oscillation, annual and semi-annual oscillations, Mesoscale circulations, The general circulations, Tropical dynamics.

(12 Lectures)

Unit 3

Atmospheric Waves: Surface water waves, wave dispersion, acoustic waves, buoyancy waves, propagation of atmospheric gravity waves (AGWs) in a nonhomogeneous medium, Lamb wave, Rossby waves and its propagation in three dimensions and in sheared flow, wave absorption, non-linear consideration.

(**12 Lectures)**

Unit 4

Atmospheric Radar and Lidar: Radar equation and return signal, Signal processing and detection, Various type of atmospheric radars, Applications of radars to study atmospheric phenomena, Lidar and its applications, Application of Lidar to study atmospheric phenomenon. Data analysis tools and techniques.

(12 Lectures)

Unit 5

Atmospheric Aerosols: Spectral distribution of the solar radiation, Classification and properties of aerosols, Production and removal mechanisms, Concentrations and size distribution, Radiative and health effects, Observational techniques for aerosol Absorption and scattering of solar radiation, Rayleigh scattering and Mie scattering, Bouguert-Lambert law, Principles of radiometry, Optical phenomena in atmosphere, Aerosol studies using Lidars.

(12 Lectures)

PRACTICAL (60 Hours)
PRACTICALS- DSE-2A LAB: Atmospheric Physics

Scilab/C++ / Fortran/ Matlab based simulations experiments based on Atmospheric Physics problems like (at least 05 experiments)

1. Numerical Simulation for atmospheric waves using dispersion relations
   - (a) Atmospheric gravity waves (AGW)
   - (b) Kelvin waves
   - (c) Rossby waves and mountain waves
2. Offline and online processing of radar data
   - (a) VHF radar,
   - (b) X-band radar, and
   - (c) UHF radar
3. Offline and online processing of LIDAR data
4. Radiosonde data and its interpretation in terms of atmospheric parameters using vertical profiles in different regions of the globe.
5. Handling of satellite data and plotting of atmospheric parameters using different techniques such as radio occultation technique
6. Time series analysis of temperature using long term data over metropolitan cities in India -an approach to understand the climate change
7. PM 2.5 measurement using compact instruments
8. Field visits to National center for medium range weather forecasting, India meteorological departments, and ARIES Nainital to see onsite radiosonde balloon launch, simulation on computers and radar operations on real time basis.

References for Theory

Essential Readings

1. Fundamental of Atmospheric Physics, M.L Salby; Academic Press, Vol 61, 1996.
2. The Physics of Atmosphere – John T. Houghton; Cambridge University press; 3rd Edn. 2002.
3. An Introduction to dynamic meteorology – James R Holton; Academic Press, 2004.
4. Radar for meteorological and atmospheric observations – S Fukao and K Hamazu, Springer Japan, 2014

DSE-2A: Physics of the Earth (42227644)
Credit: 06 (Theory-05, Tutorial-01)
Theory: 75 Hours
Tutorial: 15 Hours

Course Objective

This course familiarizes the students with the origin of universe and role of earth in the solar system.

Course Learning Outcomes

At the end of this course student will be able to

- Have an overview of structure of the earth as well as various dynamical processes occurring on it.
- Develop an understanding of evolution of the earth.
- Apply physical principles of elasticity and elastic wave propagation to understand modern global seismology as a probe of the Earth's internal structure.
- Understand the origin of magnetic field, Geodynamics of earthquakes and the description of seismic sources; a simple but fundamental theory of thermal convection; the distinctive rheological behavior of the upper mantle and its top.
- Explore various roles played by water cycle, carbon cycle, nitrogen cycles in maintaining steady state of earth leading to better understanding of the contemporary dilemmas (climate change, bio diversity loss, population growth, etc.) disturbing the Earth
- In the tutorial section, through literature survey on the various aspects of health of Earth, project work / seminar presentation, the students will be able to appreciate need to 'save' Earth.

Unit 1

The Earth and the Universe:
(a) Origin of universe, creation of elements and earth. A Holistic understanding of our dynamic planet through Astronomy, Geology, Meteorology and Oceanography. Introduction to various branches of Earth Sciences.
(b) General characteristics and origin of the Universe. The Big Bang Theory. Age of the universe and Hubble constant. Formation of Galaxies. The Milky Way galaxy, Nebular Theory, solar system, Earth's orbit and spin, the Moon's orbit and spin. The terrestrial and Jovian planets. Titius-Bode law. Asteroid belt. Asteroids: origin types and examples. Meteoroids, Meteors and Meteorites. Earth in the Solar system, origin, size, shape, mass, density, rotational and revolution parameters and its age.
(c) Energy and particle fluxes incident on the Earth. (d) The Cosmic Microwave Background.

(17 Lectures)

Unit 2

Structure:
(a) **The Solid Earth:** Mass, dimensions, shape and topography, internal structure, magnetic field, geothermal energy. How do we learn about Earth's interior?
(b) **The Hydrosphere:** The oceans, their extent, depth, volume, chemical composition. River systems.
(c) **The Atmosphere:** layers, variation of temperature with altitude, adiabatic lapse rate, variation of density and pressure with altitude, cloud formation.
(d) **The Cryosphere:** Polar caps and ice sheets. Mountain glaciers, permafrost.

(18 Lectures)

Unit 3

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

(18 Lectures)

Unit 4

Evolution:
Stratigraphy: Introduction and types, Standard stratigraphic time scale and introduction to the concept of time in geological studies. Timeline of major geological and biological events. Introduction to geochronological methods and their application in geological studies. Radiometric dating: Advantages & disadvantages of various isotopes. History of development of concepts of Uniformitarianism, Catastrophism and Neptunism. Various laws of stratigraphy. Introduction to the geology and geomorphology of Indian subcontinent. Origin of life on Earth Role of the biosphere in shaping the environment. Future of evolution of the Earth and solar system: Death of the Earth (Probable causes).

(18 Lectures)

Unit 5

Disturbing the Earth -Contemporary dilemmas
(a) Human population growth.
(b) Atmosphere: Greenhouse gas emissions, climate change, air pollution. (c) Hydrosphere: Fresh water depletion.

(d) Geosphere: Chemical effluents, nuclear waste.
(e) Biosphere: Biodiversity loss. Deforestation. Robustness and fragility of ecosystems.

(4 Lectures)

References for Theory

Essential Reading

1. Planetary Surface Processes, H. Jay Melosh, 2011, Cambridge University Press.
2. Consider a Spherical Cow: A course in environmental problem solving, John Harte, University Science Books.
3. Holme’s Principles of Physical Geology, 1992, Chapman & Hall.
4. Planet Earth, Cosmology, Geology and the Evolution of Lifeand Environment, C. Emiliani, 1992, Cambridge University Press.
5. The Blue Planet:An Introduction to Earth System Science, Brian J. Skinner, Stephen C. Portere, 1994, John Wiley & Sons.

Additional Readings

1. Physics of the Earth, Frank D. Stacey, Paul M. Davis, 2008, Cambridge University Press.
2. Fundamentals of Geophysics, William Lowrie, 1997, Cambridge University Press.
3. The Solid Earth: An Introduction to Global Geophysics, C. M. R. Fowler, 1990, Cambridge University Press.
4. The Earth: A Very Short Introduction, Martin Redfern, 2003, Oxford University Press.
5. Galaxies: A Very Short Introduction, John Gribbin, 2008, Oxford University Press.
6. Climate Change: A Very Short Introduction, Mark Maslin, 3rd Edition, 2014, Oxford University Press.
7. The Atmosphere: A Very Short Introduction, Paul I. Palmer, 2017, Oxford University Press.

DSE-2A: Biological Physics (42227645)
Credit : 06 (Theory-05, Tutorial-01)
Theory : 75 Hours
Tutorial : 15 Hours

Course Objective

This course familiarizes the students with the basic facts and ideas of biology from a quantitative perspective. It shows them how ideas and methods of physics enrich our understanding of biological systems at diverse length and time scales. The course also gives them a flavour of the interface between biology, chemistry, physics and mathematics.

Course Learning Outcomes

After completing this course, students will

- Know basic facts about biological systems, including single cells, multicellular organisms and ecosystems from a quantitative perspective.
- Gain familiarity with various biological processes at different length and time scales, including molecular processes, organism level processes and evolution.
- Be able to apply the principles of physics from areas such as mechanics, electricity and magnetism, thermodynamics, statistical mechanics, and dynamical systems to understand certain living processes.
- Gain a systems level perspective on organisms and appreciate how networks of interactions of many components give rise to complex behavior.
- Perform mathematical and computational modelling of certain aspects of living systems.

Unit 1

Overview: The boundary, interior and exterior environment of living cells. Processes: exchange of matter and energy with environment, metabolism, maintenance, reproduction, evolution. Self-replication as a distinct property of biological systems. Time scales and spatial scales. Allometric scaling laws.

(6 Lectures)

Unit 2

Molecules of life: Metabolites, proteins and nucleic acids. Their sizes, types and roles in structures and processes. Transport, energy storage, membrane formation, catalysis, replication, transcription, translation, signaling. Typical populations of molecules of various types present in cells, their rates of production and turnover. Energy required to make a bacterial cell. Simplified mathematical models of transcription and translation, small genetic circuits and signaling pathways to be studied analytically and computationally.

(18 Lectures)

Unit 3

Molecular motion in cells:
Random walks and applications to biology: Diffusion; models of macromolecules. Entropic forces: Osmotic pressure; polymer elasticity.
Chemical forces: Self-assembly of amphiphiles. Molecular motors: Transport along microtubules. Flagellar motion: bacterial chemotaxis.

(22 Lectures)

Unit 4

The complexity of life:
At the level of a cell: The numbers of distinct metabolites, genes and proteins in a cell. Metabolic, regulatory and signaling networks in cells. Dynamics of metabolic networks; the stoichiometric matrix. The implausibility of life based on a simplified probability estimate, and the origin of life problem.
At the level of a multicellular organism: Numbers and types of cells in multicellular organisms. Cellular differentiation and development.
Brain structure : Neurons and neural networks. Brain as an information processing system. At the level of an ecosystem and the biosphere: Food webs. Feedback cycles and self-sustaining ecosystems.

(20 Lectures)

References

Essential Readings

1. Biological Physics: Energy, Information, Life; Philip Nelson (W H Freeman &Co, NY, 2004).
2. Physical Biology of the Cell (2nd Edition); Rob Phillips et al (Garland Science, Taylor & Francis Group, London & NY, 2013).
3. An Introduction to Systems Biology; Uri Alon (Chapman and Hall/CRC, Special Indian Edition, 2013).
4. Evolution; M. Ridley (Blackwell Publishers, 2009), 3rd edition.

DSE-2A: Dissertation
Credit: 08

Course Objective

Dissertation involves project work with the intention of exposing the student to research /development. It involves open ended learning based on student ability and initiative, exposure to scientific writing and inculcation of ethical practices in research and communication.

Course Learning Outcomes

- Exposure to research methodology
- Picking up skills relevant to dissertation project, such as experimental skills in the subject, computational skills, etc.
- Development of creative ability and intellectual initiative
- Developing the ability for scientific writing
- Becoming conversant with ethical practices in acknowledging other sources, avoiding plagiarism, etc.

Guidelines for dissertation:

1. The dissertation work should not be a routine experiment or project at the under graduate level. It should involve more than text book knowledge. Referring text books for preparation and understanding concepts is allowed; however, one component of the dissertation must include study of research papers or equivalent research material and/or open ended project.
2. The total number of dissertations allowed should be limited to 5% of the total strength of the students in the programme. However, students having national scholarships like NTSE, KVPY, INSPIRE, etc. can be considered above this quota. The selection criterion is at the discretion of the college. The student should not have any academic backlog (Essential Repeat). The sole/single supervisor must have a Ph.D. degree. Not more than two candidates would be enrolled under same supervisor.
3. At the time of submission of teaching work-load of the teachers by the college to the Department (Department of Physics and Astrophysics, Delhi University), the supervisor shall submit the proposal (200-300 words; not more than one full A4 page) of the proposed dissertation. Along with that four names of the external examiners from any college of Delhi University (other than the own college of the supervisor) or any department of Delhi University can be suggested. The committee of courses of the department may appoint any one teacher as an external examiner from the proposed list of external examiners.
4. No topic would be repeated from the topics allotted by the supervisor in the previous years, so that the work or dissertation could be distinct every time. The 'proposal' should include the topic, plan of work, and clearly state the expected deliverables. The topic must be well defined. The abstract should clearly explain the significance of the suggested problem. It must emphasize the specific skills which the student shall be learning during the course of dissertation, for example, some computational skill or literature survey, etc. Both internal (supervisor) and external examiners will assess the

student at the end of the semester and award marks jointly, according to the attached scheme.

5. Other than the time for pursuing dissertation work, there must be at least 2 hours of interaction per week, of the student with the supervisor. The student has to maintain a "Log Book" to summarize his/ her weekly progress which shall be duly signed by the supervisor. Experimental work should be carried out in the parent college or any other college or the Department in Delhi University with the consent of a faculty member there. Unsupervised work carried out at research institutions / laboratories is to be discouraged.
6. The dissertation report should be of around 30 pages. It must have minimum three chapters namely (1) Introduction, (2) the main work including derivations / experimentation and Results, and (3) Discussion and Conclusion. At the end, adequate references must be included. Plagiarism should be avoided by the student and this should be checked by the supervisor.
7. It is left to the discretion of the college if it can allow relaxation of two teaching periods (at the most two periods per week to the supervisor, irrespective of the number of students enrolled under him / her for dissertation). The evaluation/presentation of the dissertation must be done within two weeks after the exams are over. For the interest of the students it is advised that college may organize a workshop for creating awareness amongst students. Any teacher who is not Ph.D. holder can be Co-supervisor with the main supervisor.

Assessment of dissertation

MARKING SCHEME for Dissertation:

- 30 marks: Internal assessment based on performance like sincerity, regularity, etc. Awarded by: Supervisor
- 40 marks: Written Report (including content and quality of work done). Awarded by: Supervisor and External Examiner.
- 30 marks: Presentation*. Awarded by: Supervisor and External Examiner.

*****All Dissertation presentations should be open. Other students / faculty should be encouraged to attend.

ANNEXURE-1A

Steering Committee
LOCF (CBCS) Undergraduate Physics courses revision 2019
Department of Physics & Astrophysics, University of Delhi

1. Prof. Sanjay Jain – HoD (Chairman)
2. Prof. A. G. Vedeshwar – (Coordinator)
3. Prof. Vinay Gupta – (Convener)
4. Prof. Debajyoti Choudhury
5. Prof. P. Das Gupta
6. Prof. S. Annapoorni
7. Prof. H.P. Singh
8. Prof. T.R. Seshadri
9. Prof. Anjan Dutta
10. Prof. S.K. Mandal
11. Prof. Kirti Ranjan
12. Dr. G.S. Chilana (Department of Physics, Ramjas College)
13. Dr. Mallika Verma (Department of Physics, Miranda House)
14. Dr. Anuradha Gupta (Department of Physics, SGTB Khalsha College)
15. Dr. Sangeeta D. Gadre (Department of Physics, Kirori Mal College)
16. Dr. Jacob Cherian (Department of Physics, St. Stephens' College)
17. Dr. Vandana Luthra (Department of Physics, Gargi College)
18. Dr. Mamta (Department of Physics, SGTB Khalsa College)
19. Dr. P.K. Jha (Department of Physics, Deen Dyal Upadhyaya College)
20. Dr. Sanjay Kumar (Department of Physics, St. Stephens' College)
21. Dr. Abhinav Gupta (Department of Physics, St. Stephen's College)
22. Dr. Monika Tomar (Department of Physics, Miranda House)
23. Dr. Roshan Kshetrimayum (Department of Physics, Kirori Mal College)
24. Mr. Ashish Tyagi (Department of Physics, Swami Shraddhanand College)
25. Dr. Shalini Lumb Talwar (Department of Physics, Maitreyi College)
26. Dr. Shiva Upadhyay (Department of Physics, Swami Shraddhanand College)
27. Dr. Divya Haridas (Department of Physics, Keshav Mahavidyalaya)
28. Dr. Chetana Jain (Department of Physics, Hansraj College)

ANNEXURE 1B

Subject working groups
LOCF (CBCS) Undergraduate Physics courses revision 2019
Department of Physics & Astrophysics, University of Delhi

Group	Papers	Name of faculty	Role	College
I	• Waves and Optics (Hons. core /GE) • Electricity and magnetism (Hons. core/GE) • Electromagnetic theory (Hons. core) • Electricity and magnetism (Prog. core) • Waves and Optics (Prog. core) • Electrical circuits and Networks (SEC) • Applied Optics (SEC) • Introduction to Physical Computing (SEC)	Prof. Kirti Ranjan	Coordinator	Department of Physics & Astrophysics
		Dr. Sangeeta D. Gadre	Convenor	Kirori Mal College
		Dr. Pragati Ishdhir	Member	Hindu College
		Dr. K.C. Singh		Sri Venkateswara College
		Dr. Pushpa Bindal		Kalindi College
		Dr. Geetanjali Sethi		St. Stephen's College
		Dr. Pradeep Kumar		Hansraj College
		Dr. N. Chandrlika		Gargi College
II	• Elements of Modern Physics (Hons. core/GE) • Quantum Mechanics and applications (Hons. Core) • Elements of Modern Physics (Prog. DSE) • Quantum Mechanics (Prog. DSE/GE) • Advanced Quantum Mechanics (Hons. DSE)	Prof. P. Das Gupta	Coordinator	Department of Physics & Astrophysics
		Dr. P.K. Jha	Convenor	Deen Dyal Upadhyaya college
		Dr. N. Santakrus Singh		Hindu College
		Dr. Punita Verma		Kalindi College

	• Renewable energy and Energy harvesting (SEC)	Dr. Siddharth Lahon		Kirorimal College
		Dr. Onkar Mangla		Daulat Ram College
		Dr. Sandhya		Miranda House
		Dr. Ajay Kumar		Sri Aurobindo College
III	• Thermal Physics (Hons. Core) • Statistical Mechanics (Hons. Core) • Thermal Physics and Statistical Mechanics (Program core/GE)	Prof. S. Annapoorni	Coordinator	Department of Physics & Astrophysics
		Dr. Anuradha Gupta	Convenor	SGTB Khalsa College
		Dr. Deepak Jain	Member	Deen Dyal Upadhyaya college
		Dr. Nimmi Singh		SGTB Khalsa College
		Dr. Ashok Kumar		Ramjas College
		Dr. Aditya Saxena		Deshbandhu College
		Dr. Maya Verma		Hansraj College
IV	• Solid State Physics (Hons. Core) • Solid State Physics (Prog. DSE/GE) • Nanomaterials and Applications (DSE-Hons.+ Prog.)/GE	Prof. S. Annapoorni	Coordinator	Department of Physics & Astrophysics
		Dr. Divya Haridas	Convenor	Keshav Mahavidyalaya
		Dr. Mamta Bhatia	Member	AND College
		Dr. Rajveer Singh		ARSD College
		Dr. Shiva Upadhyaya		S.S.N. College
		Dr. Harish K. Yadav		St. Stephen's College
		Dr. Rashmi Menon		Kalindi College

		Dr. Yogesh Kumar		Deshbandhu College
V	• Mathematical Physics-I (Hons. Core) • Mathematical Physics-II (Hons. Core) • Mathematical Physics -III (Hons. Core) • Advanced Mathematical Physics (Hons. DSE) • Mathematical Physics (Program DSE/ Hons. GE) • Advanced Mathematical Physics -II (Hons. DSE) • Computational Physics Skills (SEC) • Numerical Analysis (SEC) • Linear Algebra & Tensor Analysis (DSE)	Prof. T.R. Seshadri	Coordinator	Department of Physics & Astrophysics
		Dr. G.S. Chilana	Convenor	Ramjas College
		Dr. Abha Dev Habib	Member	Miranda House
		Dr. Agam Kumar Jha		Kirori Mal College
		Dr. Subhash Kumar		AND College
		Dr. Mamta		SGTB Khalsa College
		Dr. Neetu Aggarwal		Daulat Ram College
		Dr. Bhavna Vidhani		Hansraj College
		Dr. Ajay Mishra		Dyal Singh College
VI	• Mechanics (Hons. Core/GE) • Mechanics (Prog. Core) • Applied Dynamics (DSE/GE) • Classical Dynamics (DSE) • Physics Workshop Skills (SEC)	Prof. A. G. Vedeshwar	Coordinator	Department of Physics & Astrophysics
		Dr. Ashish Tyagi	Convenor	SSN College
		Dr. Shalini Lumb Talwar	Member	Maitreyi College
		Dr. Vandana Arora		Keshav Mahavidyalaya
		Dr. Arvind Kumar		Ramjas College
		Dr. Chitra Vaid		Bhagini Nivedita College
		Dr. Omwati Rana		Daulat Ram College
		Dr. Sunita Singh		Miranda House

		Dr. Pranav Kumar		Kirori Mal College
		Dr. Pooja Devi		Shyam lal College
VII	• Nuclear and particle Physics (Hons. DSE/GE) • Nuclear and particle physics (Prog. DSE) • Radiation Safety (SEC)	Prof. Samit Mandal	Coordinator	Department of Physics & Astrophysics
		Dr. Vandana Luthra	Convenor	Gargi College
		Dr. Namrata	Member	S.S.N. College
		Dr. Supriti Das		Gargi College
		Dr. Punit Tyagi		Ramjas College
VIII	• Astronomy and Astrophysics (DSE/GE) • Weather Forecasting (SEC) • Medical Physics (DSE/GE) • Atmospheric Physics (DSE/GE) • Biological Physics (DSE/GE) • Physics of Earth (DSE/GE) • Technical Drawing (SEC) • Dissertation	Prof. Anjan Datta	Coordinator	Department of Physics & Astrophysics
		Dr. Jacob Cherian	Convenor	St. Stephen's College
		Dr. S.K. Dhaka	Member	Rajdhani College
		Dr. Sanjay Kumar		St. Stephen's College
		Dr. Sushil Singh		SGTB Khalsa College
		Dr. Chetna Jain		Hansraj College
		Dr. Ayushi Paliwal		Deshbandhu College
		Dr. Rekha Gupta		St. Stephen's College
IX	• Digital Systems and Applications (Hons. Core) • Embedded Systems - Introduction to Microcontroller (DSE/GE) • Digital, Analog and Instrumentation (Prog. DSE/Hons. GE) • Verilog and FPA based System design (DSE/GE)	Prof. Vinay Gupta	Coordinator	Department of Physics & Astrophysics
		Dr. Mallika Verma	Convenor	Miranda House
		Dr. Shashi Bala	Member	Ramjas College
		Dr. Arijit Chowdhuri		AND College

	• Digital Signal Processing (DSE/GE) • Linear and Digital Integrated Circuits –E • Microprocessors and Microcontrollers –E • Electronic Instrumentation - E(DSE) • Basic Instrumentation Skills (SEC) Dissertation-E	Dr. Anjali Sharma		ARSD College
		Dr. Kajal Jindal		Kirori Mal College
		Dr. Poonam Jain		Sri Aurobindo College
		Dr. Savita Sharma		Kalindi College
		Dr. Alka Garg		Gargi College
X	• Analog systems and Applications (Hons. Core) • Experimental techniques (DSE) • Physics of Device and Communication (DSE) • Communication System (DSE/GE) • Network Analysis and Analog Electronics-E • Communication Electronics –E • Semiconductor Devices Fabrication - E(DSE) • Photonic Devices and Power Electronics -E (DSE) • Antenna theory and wireless network -E (DSE) • Electrical circuit network skills-Prog. SEC	Prof. Vinay Gupta	Coordinator	Department of Physics & Astrophysics
		Dr. Monika Tomar	Convenor	Miranda House
		Dr. Sanjay Tandon	Member	Deen Dyal Upadhyaya college
		Dr. Sangeeta Sachdeva		St. Stephen's College
		Dr. Roshan		Kirorimal College
		Dr. Kuldeep Kumar		SGTB Khalsa College
		Dr. Reema Gupta		Hindu College

XI	• Practicals of all Courses	Prof. Vinay Gupta	Coordinator	Department of Physics & Astrophysics
		Dr. Sanjay Kumar	Convenor	St. Stephen's College
		Prof. P. D. Gupta	Member	Department of Physics & Astrophysics
		Prof. A.G. Vedeshwar		Department of Physics & Astrophysics
		Prof. Samit Mandal		Department of Physics & Astrophysics
		Dr. G.S. Chilana		Ramjas College
		Dr. Mallika Verma		Miranda House
		Dr. Anuradha Gupta		SGTB Khalsa College
		Dr. Monika Tomar		Miranda House
		Dr. Sangeeta D. Gadre		Kirori Mal College
		Dr. Mamta		SGTB Khalsa College
		Dr. Vandana Luthra		Gargi College
		Dr. Roshan		Kirori Mal College

ANNEXURE 1C

Final drafting team
LOCF (CBCS) Undergraduate Physics courses revision 2019
Department of Physics & Astrophysics, University of Delhi

1. Prof. Sanjay Jain
2. Prof. A. G. Vedeshwar
3. Prof. Vinay Gupta
4. Dr. Sanjay Kumar – St. Stephens' College
5. Dr. Sangeeta Gadre – Kirori Mal College
6. Dr. Punita Verma – Kalindi College
7. Dr. Rajveer Singh – ARSD College
8. Dr. Yogesh Kumar – Deshbandhu College
9. Mrs. Poonam Jain – Sri Aurobindo College
10. Dr. Ajay Kumar – Sri Aurobindo College