# दिल्ली विश्वविद्यालय
# UNIVERSITY OF DELHI

Bachelor of Science in Physical Sciences (with Electronics)
Or
Bachelor of Science (Hons.) in Physical Sciences (with Electronics)
with Dissertation/ Academic Projects/ Entrepreneurship
Or
Bachelor of Science (Hons.) in Physical Sciences (with Electronics)
with Dissertation/ Academic Projects/ Entrepreneurship (Discipline - 1 Major)
Or
Bachelor of Science (Hons.) in Physical Sciences (with Electronics)
with Dissertation/ Academic Projects/ Entrepreneurship
(Discipline - 1 Major) and (Discipline - 2 Minor)

**Under UGCF - 2022 based on NEP - 2020**
(*Effective from Academic Year 2022-23*)

**Syllabus as approved by**

**Academic Council**
Date: No:

**Executive Council**
Date: No:

**Syllabus for Semester I and II is complete and finalized**

**Syllabus for Semester III to VIII is yet to be decided**

# TABLE OF CONTENTS


| S. No. | List of Contents | Page Number |
|---|---|---|
| | Foreword | 007 |
| | Undergraduate Curriculum Framework – 2022: Preamble | 008 |
| **1.** | UGCF 2022: Definitions and Abbreviations | 010 |
| **2.** | Features of UGCF 2022 | 012 |
| **3.** | Introduction to Undergraduate Degree Course in Physical Sciences | 015 |
| **4.** | Programme Duration and Exit Options | 015 |
| **5.** | Programme Objectives | 016 |
| **6.** | Programme Outcomes | 017 |
| **7.** | Programme Structure | 017 |
| | **7.1** Details of Discipline Specific Core (DSC) Courses | 021 |
| | **7.2** Details of Discipline Specific Elective (DSE) Courses | 023 |
| | **7.3** Details of Skill Enhancement Courses (SECs) | 026 |
| | **7.4** Details of Generic Elective (GE) Courses | 028 |
| **8.** | Teaching-Learning Process | 030 |
| **9.** | Assessment Methods | 031 |
| **10.** | Scheme of Examination | 032 |
| **11.** | Syllabus for Undergraduate Programme in Physical Sciences | 036 |
| | **11.1 Physics - Discipline Specific Core (DSC) Courses** | 036 |
| | Semester I – Physics DSC 1: Mechanics | 036 |
| | Semester I – Physics DSC 2: Network Analysis and Analog Electronics | 039 |
| | Semester II – Physics DSC 3: Electricity and Magnetism | 042 |
| | Semester II – Physics DSC 4: Linear and Digital Integrated Circuits | 045 |
| | Semester III – Physics DSC 5: Thermal Physics | 048 |
| | Semester III – Physics DSC 6: Communication Electronics | 049 |
| | Semester IV – Physics DSC 7: Waves and Optics | 050 |
| | Semester IV – Physics DSC 8: Microprocessor and Microcontroller | 051 |
| | Semester V – Physics DSC 9: Modern Physics | 052 |
| | Semester VI – Physics DSC 10: Solid State Physics | 053 |

| S. No. | List of Contents | Page Number |
|---|---|---|
| | Semester VII – Physics DSC 11: Quantum Mechanics | 054 |
| | Semester VIII – Physics DSC 12: Electromagnetic Theory | 055 |
| | **11.2 Physics - Discipline Specific Elective (DSE) Courses** | 056 |
| | Semester III – Physics DSE: Biophysics | 056 |
| | Semester III – Physics DSE: Mathematical Physics I | 057 |
| | Semester IV – Physics DSE: Numerical Analysis | 058 |
| | Semester IV – Physics DSE: Physics of Earth | 059 |
| | Semester V – Physics DSE: Semiconductor Devices Fabrication | 060 |
| | Semester V – Physics DSE: Electronics Instrumentation | 061 |
| | Semester V – Physics DSE Digital Signal Processing | 062 |
| | Semester VI – Physics DSE: Research Methodology | 063 |
| | Semester VI – Physics DSE: Verilog and FPGA based System Design | 064 |
| | Semester VI – Physics DSE: Photonic Devices and Power Electronics | 065 |
| | Semester VI – Physics DSE: Antenna Theory and Wireless Network | 066 |
| | Semester VII – Physics DSE: Physics of Materials | 067 |
| | Semester VII – Physics DSE: Introduction to Atomic and Molecular Physics | 068 |
| | Semester VII – Physics DSE: Classical Dynamics | 069 |
| | Semester VII – Physics DSE: Sensors and Detectors | 070 |
| | Semester VII – Physics DSE: Research Methodology | 071 |
| | Semester VIII – Physics DSE: Nano Science | 072 |
| | Semester VIII – Physics DSE: Nuclear and Particle Physics | 073 |
| | Semester VIII – Physics DSE: Statistical Physics | 074 |
| | Semester VIII – Physics DSE: Physics of Atmosphere and Climate Change | 075 |

| S. No. | List of Contents | Page Number |
|---|---|---|
| | **11.3 Physics - Skill Enhancement Courses (SECs)** | 076 |
| | Physics SEC 1: Basic of Instruments | 076 |
| | Physics SEC 2: Programming for Physical Applications (C/C++ or Python) | 079 |
| | Physics SEC 3: Numerical Techniques | 083 |
| | Physics SEC 4: Electric Circuits and Networks | 085 |
| | Physics SEC 5: Sensors and Detection Technology | 086 |
| | Physics SEC 6: Renewable Energy and Energy Harvesting | 087 |
| | Physics SEC 7: Introduction to Scilab Programming | 088 |
| | Physics SEC 8: Technical Drawing and 3D Printing | 092 |
| | Physics SEC 9: Data Analysis and Statistical Methods | 093 |
| | Physics SEC 10: Radiation Safety | 095 |
| | Physics SEC 11: Introduction to Physics of Devices | 099 |
| | Physics SEC 12: Introduction to Laser and Fibre Optics | 101 |
| | Physics SEC 13: Weather Forecasting | 102 |
| | Physics SEC 14: Embedded System Programming | 103 |
| | Physics SEC 15: Verilog and FPGA Programming | 104 |
| | **11.4 Physics - Generic Elective (GE) Courses** | 105 |
| | Physics GE 1: Mechanics | 105 |
| | Physics GE 2: Mathematical Physics | 108 |
| | Physics GE 3: Waves and Optics | 110 |
| | Physics GE 4: Introduction to Electronics | 113 |
| | Physics GE 5: Solid State Physics | 114 |
| | Physics GE 6: Introductory Astronomy | 115 |
| | Physics GE 7: Biological Physics | 118 |
| | Physics GE 8: Numerical Analysis and Computational Physics | 119 |
| | Physics GE 9: Applied Dynamics | 120 |
| | Physics GE 10: Quantum Information | 121 |
| | Physics GE 11: Electricity and Magnetism | 122 |
| | Physics GE 12: Thermal Physics | 126 |
| | Physics GE 13: Modern Physics | 129 |

| S. No. | List of Contents | Page Number |
|---|---|---|
| | Physics GE 14: Introductory Astronomy | 133 |
| | Physics GE 15: Quantum Mechanics | 136 |
| | Physics GE 16: Introduction to Embedded System Design | 137 |
| | Physics GE 17: Nano Physics | 138 |
| | Physics GE 18: Physics of Detectors | 139 |
| | Physics GE 19: Nuclear and Particle Physics | 140 |
| | Physics GE 20: Atomic and Molecular Physics | 141 |

# FOREWORD

The syllabus for undergraduate programme in Physics has been drafted in accordance with the recommendations of the Undergraduate Curriculum Framework 2022. The preamble, definitions and abbreviations, features and important aspects of UGCF have been incorporated in this document as mentioned in UGCF 2022. In step with the evolving trends and developments in higher education globally, UGCF 2022 distinctly integrates the objectives and underlying philosophy of National Education Policy (NEP) 2020 in its attributes. The salient features such as holistic development, academic flexibility, rootedness, life-long learning, multidisciplinary education, multilingualism, intra- and inter- university mobility, apprenticeship, research, innovation, entrepreneurship, social outreach, and the like, aim to enrich the learning experience, creativity, innovation, and skill development of the youth of our nation.

**- Drafting Committee**

# UNDERGRADUATE CURRICULUM FRAMEWORK – 2022

## PREAMBLE

The Preamble of the Undergraduate Curriculum Framework-2022 underlines the historical perspective, philosophical basis, and contemporary realities of higher education as enshrined in the National Education Policy (NEP) 2020 and endeavors to synchronize these cornerstones while charting the road ahead for the state of higher education.

The University of Delhi, a premier Institution for teaching, learning, and research in higher education, acclaimed nationally and internationally, has nurtured the quest for reaching the peak in every sphere of education, in its true sense, in the process of its contribution to the nation-building. Being a Central University, mandated to act as the torchbearer in expanding the horizons of human resource development through the expansion of higher education, it has always paid adequate premium towards constructive and meaningful innovation as a regular feature in its undergraduate curriculum development over the years.

A reflection of such sustained and continued endeavor is amply exemplified in the successive revision of undergraduate curricular framework over the decades and especially in the last two decades, keeping pace with the emerging trends in higher education in the new millennium globally and its critical importance in enriching the youth of our nation, well equipped with the prevailing priorities of skill development through innovative and practical oriented teaching-learning more than anything else.

To actualize the noble objective, as succinctly brought out in the National Education Policy 2020, the university has endeavored to explore the possibility of further restructuring and refinement of its undergraduate curriculum framework in line with the objective and underlying philosophy of the NEP 2020 to capture the imagination of the youth of our nation which depicts the contemporary realities of our demographic advantage globally.

The resultant outcome of this comprehensive exercise undertaken by the university is the Undergraduate Curriculum Framework-2022 (UGCF-2022) which not only underlines the heart and soul of the NEP 2020 in letter and spirit but also goes on to create a teaching-learning framework at the undergraduate level to attract the young minds towards research, innovation, apprenticeship, social outreach, entrepreneurship and similar such areas of human knowledge and endeavor while imbibing the truly charged academic environ of the university and its constituent colleges.

The Department of Physics and Astrophysics, University of Delhi took up the task of drafting the framework for Undergraduate Degree Course in Physical Sciences according to the

UGCF 2022 guidelines of the University of Delhi. The Committee of Courses of the Department formed subject working groups to formulate the content of different sets of courses for the first year (Semester I and Semester II). The subject working groups included teachers from various constituent colleges of the University, who have experience of teaching the respective courses. Faculty members from the Department of Physics and Astrophysics have also contributed to this important task. The inputs of the subject working groups were compiled, and the present document was prepared by a final drafting team.

## 1. UGCF-2022: Definitions and Abbreviations

**(a) Academic credit:** An academic credit is a unit by which the course work is measured. It determines the number of hours of instructions required per week. One credit is equivalent to one hour of teaching (lecture or tutorial) or two hours of practical work/field work per week.

**(b) Courses of study:** Courses of the study indicate pursuance of study in a particular discipline. Every discipline shall offer four categories of courses of study, *viz.* Discipline Specific Core courses (DSCs), Discipline Specific Electives (DSEs), Skill Enhancement Courses (SECs) and Generic Electives (GEs). Besides these four courses, a student will select Ability Enhancement Courses (AECs) and Value-Added Courses (VACs) from the respective pool of courses offered by the University.

**(i) Discipline Specific Core (DSC):** Discipline Specific Core is a course of study, which should be pursued by a student as a mandatory requirement of his/her programme of study. In B. Sc. (Hons.) Physical Sciences programme, DSCs are the core credit courses of Physics, Electronics and Mathematics (See Table - 2) which will be appropriately graded and arranged across the semesters of study, being undertaken by the student, with multiple exit options as per NEP 2020. A student will study three DSC Courses each, in Semesters I to VI (See Table - 3). In semesters VII and VIII the student has to study two DSC courses from any one of the disciplines; Physics or Electronics Mathematics, and not a combination of these.

**(ii) Discipline Specific Elective (DSE):** The Discipline Specific Electives (DSEs) are a pool of credit courses of Physics, Electronics and Mathematics. A student gets an option of choosing one DSE course in each of the semesters III to VI from a pool of DSE courses as specified in Table - 4. In semesters VII and VIII the student has an option of choosing a maximum of three DSE courses from any one of the disciplines; Physics or Electronics or Physics or Mathematics, and not a combination of Physics/Electronics/Mathematics.

**(iii) Generic Elective (GE):** Generic Electives is a pool of courses offered by various disciplines of study which is meant to provide multidisciplinary or interdisciplinary education to students. In case a student opts for DSEs beyond his/her discipline-specific course(s) of study, such DSEs shall be treated as GEs for that student. In semesters I, II, V and VI, a student has to compulsorily study one GE course from a pool of courses offered by the institution. However, in semesters III and IV a student has an option of choosing either a DSE course in Physics/Electronics/Mathematics or a GE course of any discipline offered by the institution. Similarly, in semesters VII and VIII, a student can exercise an option of choosing a maximum of two Generic Elective courses out of a combination of DSE and GE courses.

**(iv) Ability Enhancement Course (AEC), Skill Enhancement Course (SEC) and Value Addition Course (VAC)**

These three courses are a pool of courses offered by all the Departments in groups of odd and even semesters from which a student can choose. A student who desires to make Academic

Project/ Entrepreneurship as Minor has to pick the appropriate combination of courses of GE, SEC, VAC, and Internship/ Apprenticeship/ Project/ Community (IAPC) which shall be offered in the form of various modules as specified in the scheme of studies.

- **AEC courses** are the courses based upon the content that leads to knowledge enhancement through various areas of study. They are Language and Literature and Environmental Science and Sustainable Development which are mandatory for all disciplines. Every student has to study "Environmental Science and Sustainable Development" courses I and II of two credits each in the first year (I/II semester) and the second year (III/IV semester), respectively. The AEC pool consists of credit courses in languages listed in the Eighth Schedule of the Constitution of India, as updated from time to time.

- **SECs** are skill-based courses in all disciplines and are aimed at providing hands-on training, competencies, proficiency and skills to students. SEC courses may be chosen from a pool of courses designed to provide skill-based instruction in all the three discipline of study i.e. Physics, Electronics and Mathematics.
  A student will study one Skill Enhancement Course of 2 credits each (following 1T+1P/ 0T+2P credit system) in all the semesters, from semester I to VI. It is to be noted that in the semesters III, IV, V and VI; students can choose either one SEC paper or can join any Internship/ Apprenticeship/ Project (following two credit system).

- **VAC courses** are common pool of courses offered by different disciplines and aimed towards personality building, embedding ethical, cultural and constitutional values; promote critical thinking, Indian knowledge systems, scientific temperament, communication skills, creative writing, presentation skills, sports and physical education and team work which will help in all round development of students.

## 2. Features of UGCF 2022

The Undergraduate Curriculum Framework 2022 (UGCF 2022) is meant to bring about systemic change in the higher education system in the University and align itself with the NEP 2020. The objectives of the NEP 2020 have been reflected in the following features of UGCF 2022:

**a) Holistic Development**

Holistic development of the students shall be nurtured through imparting life skills in initial years. These life skill courses shall include courses on 'Environment and Sustainable Development Studies', 'Communication Skills', 'Ethics and Culture', 'Science and Society', 'Computational Skills', 'IT and Data Analytics', and similar such skills which shall make the students better equipped to deal with the life's challenges.

**b) Academic Flexibility**

Flexibility to the students to determine their learning trajectories and pursuance of programmes of study has been well ingrained in the UGCF 2022. The Framework allows students to opt for one, two, or more discipline(s) of study as a core discipline(s) depending on his/her choice. He/she has been provided the option of focusing on studying allied courses of his/her selected discipline(s) (DSEs) or diversifying in other areas of study of other disciplines. Students have also been provided with the flexibility to study SECs or opt for Internships or Apprenticeship or Projects or Research or Community Outreach at an appropriate stage. In the fourth year, students are provided flexibility to opt for writing a dissertation (on major, minor, or combination of the two) or opt for Academic Projects or Entrepreneurship depending upon their choice and their future outlook, post completion of their formal education.

**c) Multiple Exits/ Re-entry/ Academic Bank of Credit (ABC)/ Academic Outreach**

Given the extent of plurality of the Indian society and the diverse background to which students belong, multiple exits and provision of re-entry have been provided at various stages of the undergraduate programme to accommodate their requirement and facilitate them to complete their studies depending upon their priorities of life. The earning and accumulation of credits in the Academic Bank of Credit (ABC), and the flexibility to redeem the requisite credit for award of appropriate Certificate/Diploma/Degree, as the per the norms laid down by the UGC and the University, shall be made available to the students to provide the opportunity for lifelong learning as well as for availing academic outreach beyond the superstructure of the programme of study in another University/Institution at the national/international level depending upon individual choice of the student(s).

**d) Multidisciplinary Education**

UGCF 2022 has incorporated multidisciplinary education by providing an opportunity to study multidisciplinary courses. In B.Sc. (Hons.) Physical Sciences, a student can study DSC, DSE and SEC courses of Physics or Electronics or Mathematics. More importantly a student can choose to study Generic Elective (GE) courses in all the disciplines offered by the college. Further, a student pursuing multidisciplinary course of study may obtain a Major and a Minor in two different disciplines if she/he completes the credit requirements.

The framework does not maintain/support hierarchy among fields of study/disciplines and silos between different areas of learning. As long as a student fulfills the pre-requisites of a course of study, he/she shall be able to study it. Modules or systems of study shall be meaningfully laid down so as to guide the students in choosing the track/academic paths for the desired outcome.

**e) Multilingualism**

One of the significant hallmarks of the framework is a provision of pursuing multilingualism while studying any other discipline as core subject(s), which has no bearing with any language and linguistics. I and II semesters of the programme provides an opportunity to the students to study languages which are enshrined under the eighth schedule of the Constitution of India, thereby allowing the students for their holistic development, including the ability to acquire proficiency in a language beyond their mother tongue.

**f) Research and Innovation**

The framework provides a mandatory programme on research methodologies as one of the discipline specific elective (DSE) courses at the VI and VII semester for students who opt for writing dissertation on major or minor or interdisciplinary at VII and VIII semesters. Dissertation/Academic Project/Entrepreneurship in the 4 year shall commence from VII semester and conclude in VIII semester. Detailed outcomes of each track chosen out of these three options shall be notified and assessment at the end of VII and VIII semesters shall be done accordingly. Further, provision for internship/apprenticeship/project/community outreach right from the III semester up to VI semester provides ample opportunity to the students to explore areas of knowledge/activity beyond the four walls of the classroom and reach out to the world outside without any dilution of the academic feature of the course of study, he/she is pursuing. This also acts a precursor for the students to take up academic project or entrepreneurship at a later stage in VII and VIII semester. Such an initiative will help in skill development and laying a strong foundation for research and thus contribute towards overall national development through the development of skilled manpower and innovation.

**g) Intra- and Inter-university Mobility**

Intra- and inter- University mobility of students is another element of critical importance which has been ingrained in the framework. A student, by virtue of such mobility, will be able to make lateral movement within the University as well as from the University to any other Institution and vice-versa. Such an attribute allows a student maximum flexibility in terms of pursuance of education with special reference to higher education and enables him/ her to achieve goal in life, the way he/she perceived it.

Based on the aforementioned features of UGCF 2022, the University expects maximum involvement of the student fraternity in utilizing the benefits of such a flexible yet rigorous curriculum framework at the undergraduate level and reaping the benefits of it through enrichment of their skills in their area of interest which will eventually help them in gaining employment, entrepreneurship, start-ups and various other ways of a dignified life and living as a global citizen with comparable skills and innovative ideas befitting to the contemporary global demands. The university expects the youthful nation to reap the maximum benefits out of the UGCF 2022 in developing skilled manpower to harness the youthful energy at one hand and expand the permeation of the skilled workforce globally, taking the demographic advantage on the other hand.

## 3. Introduction to Undergraduate Degree course in Physical Sciences

As per the recommendations of UGCF 2022, the undergraduate degree course in Physical Sciences is a six/eight-semester course spread over three/ four academic years. The teaching-learning process is student-centric and it involves both theory and practical components. It offers a flexibility of programme structure while ensuring that the student gets a strong foundation in the subject and gains in-depth knowledge. Besides the DSCs of three different disciplines i.e. Physics or Electronics or Mathematics, a student can opt courses from the syllabus comprising of DSEs, GEs, SECs, AECs and VACs. Thereby, bringing out the multidisciplinary approach and adherence to innovative ways within the curriculum framework. Moreover, it allows a student maximum flexibility in pursuing his/her studies at the undergraduate level to the extent of having the liberty to eventually design the degree with multiple exit options depending upon the needs and aspirations of the student in terms of his/her goals of life, without compromising on the teaching learning, both in qualitative and quantitative terms. This will suit the present day needs of students in terms of securing their paths towards higher studies or employment.

## 4. Programme Duration and Exit Options

The minimum credit to be earned by a student per semester is 18 credits and the maximum is 26 credits. However, students are advised to earn 22 credits per semester. This provision is meant to provide students the comfort of the flexibility of semester-wise academic load and to learn at his/her own pace. However, the mandatory number of credits has to be secured for the purpose of award of Undergraduate Certificate/Undergraduate Diploma/Appropriate Bachelor of Science degree in Physical Science as listed in Table 1.

**Table 1: Qualification Type and Credit Requirements**

| S. No. | Type of Award | Stage of Exit | Mandatory credits to be secured for the award |
|---|---|---|---|
| 1 | Undergraduate Certificate in Physical Sciences | After successful completion of Semester II | 44 |
| 2 | Undergraduate Diploma in Physical Sciences | After successful completion of Semester IV | 88 |
| 3 | Bachelor of Science in Physical Sciences | After successful completion of Semester VI | 132 |
| 4 | Bachelor of Science (Hons.) in Physical Sciences with Dissertation/Academic Projects/ Entrepreneurship | After successful completion of Semester VIII | 176 |
| 5 | Bachelor of Science (Hons.) in Physical Sciences with Dissertation/Academic Projects/ Entrepreneurship (Discipline-1Major) | After successful completion of Semester VIII | 176 |
| 6 | Bachelor of Science (Hons.) in Physical Sciences with Dissertation/Academic Projects/ Entrepreneurship (Discipline - 1 Major) and (Discipline - 2 Minor) | After successful completion of Semester VIII and credit requirements for Major & Minor | 176 |

## Major Discipline

A student pursuing four-year undergraduate programme in Physical Sciences shall be awarded B.Sc. Honours Physical Sciences degree with Major in Physics/Electronics/ Mathematics on completion of VIII Semester, if he/she secures at least 80 credits in Physics/Electronics/Mathematics out of the total of 176 credits. He/she shall study 6 DSCs and at least 3 DSEs in the respective discipline (Physics/Electronics/ /Mathematics) in the first six semesters and 2 DSCs, 6 DSEs and write dissertation in respective discipline (Physics/Electronics/Mathematics) in the VII and VIII semester.

## Minor Discipline

A student of B.Sc. (Hons.) Physical Sciences may be awarded Minor in a discipline (Physics/Electronics/Mathematics), on completion of VIII Semester, if he/she earns minimum 28 credits from six DSCs and one DSE of that discipline.

For instance, a student who pursues 4 years B.Sc. (Hons.) Physical Sciences, if he/she earns minimum 80 credits in Physics from 8 DSCs and at least 9 DSEs from Physics and writes dissertation on a topic of Physics discipline, then he/she will earn Major in Physics. Such a student shall get a minor in Electronics/Mathematics, if he/she earns minimum 28 credits from 6 DSCs and 1 DSE of Electronics/Mathematics.

## 5. Programme Objectives

The undergraduate degree course in Physical Sciences aims to provide:

- In-depth knowledge in Electronics, physics and mathematics through understanding of key concepts, principles, theories and manifestations of the three disciplines.
- Competence and skill in solving both theoretical and applied problems in different disciplines.
- A conducive learning environment that ensures holistic cognitive development of students.
- Exposure to the latest advances in Electronics, physics, mathematics and research.
- Development of critical and analytical thinking, scientific reasoning, problem-solving skills, communication skills and teamwork.
- Moral and ethical awareness, leadership qualities and innovation.
- Multicultural competence and multilinguism.
- Knowledge and skill to undertake higher studies in Electronics, physics, mathematics and related areas thereby enabling students' employment/entrepreneurship.
- Sufficient subject matter competence and enable students to prepare for various competitive exams, such as IIT-JAM, GATE, GRE, UGC-CSIR NET/JRF and Civil Services Examinations.

## 6. Program Outcomes

The programme learning outcomes of the undergraduate degree course in Physical Sciences are as follows:

- **In-depth knowledge**: The student will acquire theoretical knowledge and understanding of the fundamental concepts, principles and processes in the three different disciplines Electronics, physics and mathematics. The core papers will provide in-depth understanding of the subject. A wide choice of elective courses offered to the student will provide specialized understanding rooted in the core and interdisciplinary areas.
- **Hands-on/ Laboratory Skills:** Comprehensive hands-on/ laboratory exercises will impart analytical, computational and instrumentation skills. The students will be able to demonstrate mature skills for the collating, evaluation, analysis and presentation of information, ideas, concepts and quantitative and/or qualitative data.
- **Research skills:** The course provides an opportunity to students to hone their research and innovation skills through internship/ apprenticeship/ project/ community outreach/ dissertation/Academic Project/ Entrepreneurship. It will enable the students to demonstrate mature skills in literature survey, information management skills, and data analysis and research ethics.
- **Role of Physical Sciences**: The students will develop awareness and appreciation for the significant role played by Electronics, physics and mathematics in current societal and global issues, including areas such as sustainable development. They will be able to address and contribute to such issues through the skills and knowledge acquired during the programme.
- **Communication and IT Skills:** Various DSCs, DSEs, SECs, GEs and AECs have been designed to enhance student's ability to write methodical, logical and precise reports. The courses will, in addition, guide the student to communicate effectively through oral/poster presentations, writing laboratory/ project reports and dissertations. Several IT based papers in DSEs and SECs will enable students to develop expertise in general and subject specific computational skills.
- **Lateral Thinking**: The programme will develop the ability to apply the underlying concepts and principles of Electronics, physics and mathematics, and allied fields beyond the classrooms to real life applications, innovation and creativity.
- **Competence and Job Opportunities**: The skills acquired during the programme will provide varied opportunities for students' career progression. They will be able to join analytical, chemical, pharmaceutical, biochemical, material testing, fast moving consumer goods (FMCG) and other industries/laboratories, academics, innovation and research at different exit points.

## 7. Programme Structure

The detailed framework of undergraduate degree programme in Physical Sciences is provided **in Table 2.**

## Table 2
## Structure of Undergraduate Programme in Physical Sciences under UGCF 2022

| Semester | Discipline Specific Core (DSC) (4) | Discipline Specific Elective(DSE) (4) | Generic Elective (GE) (4) | Ability Enhancement Course (AEC) (2) | Skill Enhancement Course (SEC) (2) | Internship/ Apprenticeship/ Project/Community Outreach (IAPC) (2) | Value Addition Course (VAC) (2) | Total Credits |
|---|---|---|---|---|---|---|---|---|
| I | DSC 1: Physics 1 (2T+2P)<br>DSC 2: Electronics 1 (2T+2P)<br>DSC 3: Mathematics 1 | NA | Choose one from a pool of courses GE 1 (2T+2P)/ (3T+1P)/ (3T+1Tut) | Choose one AEC from a pool of courses | Choose one from a pool of courses (0T+2P)/ (1T+1P) | NA | Choose one from a pool of courses | **22** |
| II | DSC 4: Physics 2 (2T+2P)<br>DSC 5: Electronics 2 (2T+2P)<br>DSC 6: Mathematics 2 | NA | Choose one from a pool of courses GE 2 (2T+2P)/ (3T+1P)/ (3T+1Tut) | Choose one AEC from a pool of courses | Choose one from a pool of courses (0T+2P)/ (1T+1P) | NA | Choose one from a pool of courses | **22** |
| **Students on exit shall be awarded Undergraduate Certificate in Physical Sciences after securing the requisite 44 credits in Semester I and II** | | | | | | | | **Total = 44** |
| III | DSC 7: Physics 3 (2T+2P)<br>DSC 8: Electronics 3 (2T+2P)<br>DSC 9: Mathematics 3 | Choose one from a pool of courses<br>DSE 1 (4T+0P)/(2T+2P) Physics/Electronics/Mathematics<br>OR<br>GE 3 (2T+2P)/ (3T+1P)/ (3T+1Tut) | | Choose one AEC from a pool of courses | Choose one SEC (0T+2P) or (1T+1P)<br>OR<br>IAPC** | | Choose one from a pool of courses | **22** |
| IV | DSC 10: Physics 4 (2T+2P)<br>DSC 11: Electronics 4 (2T+2P)<br>DSC 12: Mathematics 4 | Choose one from a pool of courses<br>DSE 2 (4T+0P)/(2T+2P) Physics/Electronics/Mathematics<br>OR<br>GE 4 (2T+2P)/ (3T+1P)/ (3T+1Tut) | | Choose one AEC from a pool of courses | Choose one SEC (0T+2P) or (1T+1P)<br>OR<br>IAPC** | | Choose one from a pool of courses | **22** |
| **Students on exit shall be awarded Undergraduate Diploma in Physical Sciences after securing the requisite 88 credits after completion of Semester IV** | | | | | | | | **Total = 88** |

| Semester | Discipline Specific Core (DSC) (4) | Discipline Specific Elective(DSE) (4) | Generic Elective (GE) (4) | Ability Enhancement Course (AEC) (2) | Skill Enhancement Course (SEC) (2) | Internship/ Apprenticeship/ Project/Community Outreach (IAPC) (2) | Value Addition Course (VAC) (2) | Total Credits |
|---|---|---|---|---|---|---|---|---|
| **V** | DSC 13: Physics 5 (2T+2P)<br>DSC 14: Electronics 5<br>DSC 15: Mathematics 5 | Choose one from a pool of courses DSE 3 (4T+0P)/(2T+2P) Physics/Electronics/ Mathematics | Choose one form a pool of courses GE 5 (2T+2P)/(3T+1P)/ (3T+1Tut) | NA | Choose one SEC (0T+2P) or (1T+1P)<br>OR<br>IAPC** | | NA | **22** |
| **VI** | DSC 16: Physics 6 (2T+2P)<br>DSC 17: Electronics 6<br>DSC 18: Mathematics 6 | Choose one from a pool of courses DSE 4 (4T+0P)/(2T+2P) *** Physics/Electronics/ Mathematics | Choose one form a pool of courses GE 6 (2T+2P)/(3T+1P)/ (3T+1Tut) | NA | Choose one SEC (0T+2P) or (1T+1P)<br>OR<br>IAPC** | | NA | **22** |
| **Students on exit shall be awarded Bachelor of Science in Physical Sciences after securing the requisite 132 credits on completion of Semester VI** | | | | | | | | **Total = 132** |
| **VII** | DSC 19<br>Physics 7 (4T+0P)<br>OR<br>Electronics 7<br>OR<br>Mathematics 7 | Choose three DSE courses #<br>OR<br>Choose two DSE# and one GE course<br>OR<br>Choose one DSE# and two GE courses | | NA | NA | NA | Dissertation on Major (6) OR Dissertation on Minor (6) OR Academic project/ Entrepreneurship (6) | **22** |
| **VIII** | DSC 20<br>Physics 8 (4T+0P) OR<br>Electronics 8 OR<br>Mathematics 8 | Choose three DSE# courses<br>OR<br>Choose two DSE# and one GE course<br>OR<br>Choose one DSE# and two GE courses | | NA | NA | NA | Dissertation on Major (6) OR Dissertation on Minor (6) OR Academic project/ Entrepreneurship (6) | **22** |
| **Students on exit shall be awarded Bachelor of Science (Hons.) with Research/Academic Projects/Entrepreneurship or Appropriate Bachelor of Science (Hons.) with Research/Academic Projects/Entrepreneurship (Discipline-1 Major) and (Discipline-2 Minor) after securing the requisite 176 credits on completion of Semester VIII** | | | | | | | | **Total = 176** |

* There shall be choice in Semesters III and IV to either choose a DSE course from a pool of DSE courses offered by Electronics, Physics and Mathematics disciplines OR a GE course from a pool of GE courses offered by all the disciplines in the college. A DSE course if chosen from other discipline except Electronics, Physics and Mathematics, such a course will be considered as a GE course.

** There shall be choice in Semesters III and IV to choose either one ‘SEC’ or in the alternative ‘Internship/Apprenticeship/Project/Community Outreach (IAPC)’ in each Semester of two credits each.

*** **‘Research Methodology’** shall be offered as one of the DSE courses in VI and VII. If a student wishes to pursue four years B.Sc. (Hons.) Physical Science with Academic Project/Entrepreneurship, he/she shall compulsorily opt for a Research Methodology course in either Semester VI or VII.

# In semesters VII and VIII a student will have the option to choose DSE courses from any one of the discipline Electronics/Physics/Mathematics, and not a combination of these disciplines. The following choices will be available in VII and VIII semesters:

(i) to choose three DSEs of 4 credits each either from Physics or Electronics or Mathematics (not a combination of these disciplines)

**OR**

(ii) to choose two DSEs of 4 credits each either from Physics or Electronics or Mathematics (not a combination of these disciplines) and one GE of 4 credits

**OR**

(iii) to choose one DSE of 4 credits either from Physics or Electronics or Mathematics and two GEs of 4 credits each.

Note:

The size of the group for Physics practical papers is recommended to be a maximum of 20 students.

The size of the group for Physics tutorial hours is recommended to be a maximum of 16 students.

### 7.1 Semester-wise Distribution of Discipline Specific Core (DSC) Courses

A student will study three Discipline Specific Core Courses each, in Semesters I to VI. In semesters VII and VIII the student has to study two DSC courses from any one of the disciplines; Physics or Electronics or Mathematics, and not a combination of these.
The semester wise distribution of DSC courses over eight semesters is listed in **Table 3**.

**Table 3**
**Semester-wise Distribution of Discipline Specific Core (DSC) Courses**

| DISCIPLINE SPECIFIC CORE COURSES (4 Credits each) | | | |
|---|---|---|---|
| **SEMESTER** | **COURSE CODE** | **NAME OF THE COURSE** | **CREDITS**<br>**T = Theory Credits**<br>**P = Practical Credits** |
| **I** | Physics DSC 1 | Mechanics | T = 2<br>P = 2 |
| | Physics DSC 2 | Network Analysis and Analog Electronics | T = 2<br>P = 2 |
| | DSC Mathematics 1 | | |
| **II** | Physics DSC 3 | Electricity and Magnetism | T = 2<br>P = 2 |
| | Physics DSC 4 | Linear and Digital Integrated Circuits | T = 2<br>P = 2 |
| | DSC Mathematics 2 | | |
| **III** | Physics DSC 5 | Thermal Physics | T = 2<br>P = 2 |
| | Physics DSC 6 | Communication Electronics | T = 2<br>P = 2 |
| | DSC Mathematics 3 | | |
| **IV** | Physics DSC 7 | Waves and Optics | T = 2<br>P = 2 |
| | Physics DSC 8 | Microprocessor and Microcontroller | T = 2<br>P = 2 |
| | DSC Mathematics 4 | | |

| DISCIPLINE SPECIFIC CORE COURSES (4 Credits each) | | | |
|---|---|---|---|
| **SEMESTER** | **COURSE CODE** | **NAME OF THE COURSE** | **CREDITS**<br>**T = Theory Credits**<br>**P = Practical Credits** |
| **V** | Physics DSC 9 | Modern Physics | T = 2<br>P = 2 |
| | DSC Electronics | | |
| | DSC Mathematics 5 | | |
| **VI** | Physics DSC 10 | Solid State Physics | T = 2<br>P = 2 |
| | DSC Electronics | | |
| | DSC Mathematics 6 | | |
| **VII** | Physics DSC 11 | Quantum Mechanics | T = 4<br>P = 0 |
| **VIII** | Physics DSC 12 | Electromagnetic Theory | T = 4<br>P = 0 |

### 7.2 Details of Discipline Specific Elective (DSE) Courses

The DSE courses will be offered to students from all the three disciplines *viz*., Physics, Electronics and Mathematics in each of the semesters; III, IV, V, and VI as listed below in **Table 4**. The DSE courses are distributed in Pool A (Pool for Odd Semesters) and Pool B (Pool for Even Semesters), to be offered to students in odd and even semesters, respectively as specified in the Table 4. A student studying in semester III and V will have an option of choosing any DSE course of his/her choice as floated by the respective college from Pool A. Similarly, a student studying in semester IV and VI will have an option of choosing any DSE course of his/her choice as floated by the college from Pool B. It is to be noted that the college will offer at least one DSE course from each of the three disciplines i.e., Physics, Electronics and Mathematics. There shall be choice in Semesters III and IV to either choose a DSE course from a pool of DSE courses offered by Physics, Electronics and Mathematics disciplines OR a GE course from a pool of GE courses offered by all the disciplines in the college. A DSE course if chosen from other discipline except Physics, Electronics and Mathematics, such a course will be considered as a GE course. In semesters VII and VIII a student will have the option to choose DSE courses from any one of the discipline Physics/Electronics/Mathematics, and not a combination of these disciplines.

**Table 4**
**Details of Discipline Specific Elective (DSE) Courses**

| DSE COURSES (4 Credits each) | | |
|---|---|---|
| **COURSE CODE** | **NAME OF THE COURSE** | **CREDITS**<br>**T = Theory Credits**<br>**P = Practical Credits**<br>**Tut = Tutorial Credits** |
| **POOL FOR PHYSICS PAPERS FOR ODD SEMESTERS** | | |
| Physics DSE 1 | Biophysics<br><br>(To Be Offered In Semester 3) | T = 4<br>P = 0 |
| Physics DSE 2 | Mathematical Physics I<br><br>(To Be Offered In Semester 3) | T = 4<br>P = 0 |
| Physics DSE 3 | Semiconductor Devices Fabrication<br><br>(To Be Offered In Semester 5) | T = 2<br>P = 2 |
| Physics DSE 4 | Electronics Instrumentation<br><br>(To Be Offered In Semester 5) | T = 2<br>P = 2 |
| Physics DSE 5 | Digital Signal Processing<br><br>(To Be Offered In Semester 5) | T = 2<br>P = 2 |
| Physics DSE 6 | Physics of Materials<br><br>(To Be Offered In Semester 7) | T = 2<br>P = 2 |
| Physics DSE 7 | Introduction to Atomic and Molecular Physics<br><br>(To Be Offered In Semester 7) | T = 4<br>P = 0 |
| Physics DSE 8 | Classical Dynamics<br><br>(To Be Offered In Semester 7) | T = 3<br>P = 0<br>Tut = 1 |
| Physics DSE 9 | Sensors and Detectors<br><br>(To Be Offered In Semester 7) | T = 2<br>P = 2 |
| Physics DSE 10 | Research Methodology<br><br>(To Be Offered In Semester 7) | T = 4<br>P = 0 |

| DSE COURSES (4 Credits each) | | |
|---|---|---|
| **COURSE CODE** | **NAME OF THE COURSE** | **CREDITS**<br>**T = Theory Credits**<br>**P = Practical Credits** |
| **POOL FOR PHYSICS PAPERS FOR EVEN SEMESTERS** | | |
| Physics DSE 11 | Numerical Analysis<br><br>(To Be Offered In Semester 4) | T = 2<br>P = 2 |
| Physics DSE 12 | Physics of Earth<br><br>(To Be Offered In Semester 4) | T = 4<br>P = 0 |
| Physics DSE 13 | Research Methodology<br><br>(To Be Offered In Semester 6) | T = 4<br>P = 0 |
| Physics DSE 14 | Verilog and FPGA based System Design<br><br>(To Be Offered In Semester 6) | T = 2<br>P = 2 |
| Physics DSE 15 | Photonic Devices and Power Electronics<br><br>(To Be Offered In Semester 6) | T = 2<br>P = 2 |
| Physics DSE 16 | Antenna Theory and Wireless Network<br><br>(To Be Offered In Semester 6) | T = 2<br>P = 2 |
| Physics DSE 17 | Nano Science<br><br>(To Be Offered In Semester 8) | T = 2<br>P = 2 |
| Physics DSE 18 | Nuclear and Particle Physics<br><br>(To Be Offered In Semester 8) | T = 4<br>P = 0 |
| Physics DSE 19 | Statistical Physics<br><br>(To Be Offered In Semester 8) | T = 4<br>P = 0 |
| Physics DSE 20 | Physics of Atmosphere and Climate Change<br><br>(To Be Offered In Semester 8) | T = 3<br>P = 1 |

**Note:** It is to be ensured that while choosing DSEs or SECs or GEs a student should not opt for a paper where the course content is similar to the paper previously studied by the student.

### 7.3 Details of Skill Enhancement Courses (SECs)

To enhance the skills required for advanced studies, research and employability of students various Skill Enhancement Courses will be offered to students as listed in **Table 5**.

The SEC courses will be offered to students from all the three disciplines *viz*., Physics, Electronics and Mathematics in each of the semesters; I, II, III, IV, V, and VI as listed below in Table 5. The SEC courses are distributed in Pool A (Pool for Odd Semesters) and Pool B (Pool for Even Semesters), to be offered to students in odd and even semesters, respectively as specified in the **Table 5**. A student studying in semester I, III and V will have an option of choosing any SEC course of his/her choice as floated by the respective college from Pool A. Similarly, a student studying in semester II, IV and VI will have an option of choosing any SEC course of his/her choice as floated by the college from Pool B. It is to be noted that the college will offer at least one SEC course from each of the three disciplines i.e. Physics, Electronics and Mathematics in each semester. Any other SEC course may also be floated by a college from the central pool of each discipline.

There shall be a choice in Semesters III, IV, V and VI to either choose an SEC course from a pool of SEC courses offered by Physics, Electronics and Mathematics disciplines OR to choose Internship/Apprenticeship/Project/Community Outreach (IAPC).

## Table 5
## Details of Skill Enhancement Courses Offered by Physics

| SKILL ENHANCEMENT COURSE (2 Credits each) | | |
|---|---|---|
| **COURSE CODE** | **NAME OF THE COURSE** | **CREDITS**<br>**T = Theory Credits**<br>**P = Practical Credits** |
| **POOL A: (TO BE OFFERED IN SEMESTERS 1/3/5)** | | |
| Physics SEC 1 | Basic of Instruments | T = 0<br>P = 2 |
| Physics SEC 2 | Programming for Physical Applications (C/C++ or Python) | T = 0<br>P = 2 |
| Physics SEC 3 | Numerical Techniques | T = 0<br>P = 2 |
| Physics SEC 4 | Electric Circuits and Networks | T = 0<br>P = 2 |
| Physics SEC 5 | Sensors and Detection Technology | T = 1<br>P = 1 |
| Physics SEC 6 | Renewable Energy and Energy Harvesting | T = 1<br>P = 1 |
| Physics SEC 7 | Introduction to Scilab Programming | T = 0<br>P = 2 |
| Physics SEC 8 | Technical Drawing and 3D Printing | T = 0<br>P = 2 |

| SKILL ENHANCEMENT COURSE (2 Credits each) | | |
|---|---|---|
| **COURSE CODE** | **NAME OF THE COURSE** | **CREDITS**<br>**T = Theory Credits**<br>**P = Practical Credits** |
| **POOL B: (TO BE OFFERED IN SEMESTERS 2/4/6)** | | |
| Physics SEC 9 | Data Analysis and Statistical Methods | T = 0<br>P = 2 |
| Physics SEC 10 | Radiation Safety | T = 1<br>P = 1 |
| Physics SEC 11 | Introduction to Physics of Devices | T = 1<br>P = 1 |
| Physics SEC 12 | Introduction to Laser and Fibre Optics | T = 1<br>P = 1 |
| Physics SEC 13 | Weather Forecasting | T = 1<br>P = 1 |
| Physics SEC 14 | Embedded System Programming | T = 0<br>P = 2 |
| Physics SEC 15 | Verilog and FPGA Programming | T = 0<br>P = 2 |

**7.4 Details of Generic Elective (GE) Courses Offered by Physics**

Generic Elective courses provide multidisciplinary or interdisciplinary education to students. Various GE courses offered by the Physics Department are listed below in **Table 6**.

**Table 6**
**Details of Generic Elective (GE) Courses**

| GENERIC ELECTIVE COURSE (4 Credits each) | | |
|---|---|---|
| **COURSE CODE** | **NAME OF THE COURSE** | **CREDITS**<br>**T = Theory Credits**<br>**P = Practical Credits**<br>**Tut = Tutorial Credits** |
| **POOL A**<br><br>**(TO BE OFFERED IN SEMESTERS 1/3/5/7)** | | |
| Physics GE 1 | Mechanics | T = 3<br>P = 1<br>Tut = 0 |
| Physics GE 2 | Mathematical Physics | T = 3<br>P = 0<br>Tut = 1 |
| Physics GE 3 | Waves and Optics | T = 3<br>P = 1<br>Tut = 0 |
| Physics GE 4 | Introduction to Electronics | T = 2<br>P = 2<br>Tut = 0 |
| Physics GE 5 | Solid State Physics | T = 3<br>P = 0<br>Tut = 1 |
| Physics GE 6 | Introductory Astronomy | T = 3<br>P = 0<br>Tut = 1 |
| Physics GE 7 | Biological Physics | T = 3<br>P = 0<br>Tut = 1 |
| Physics GE 8 | Numerical Analysis and Computational Physics | T = 2<br>P = 2<br>Tut = 0 |
| Physics GE 9 | Applied Dynamics | T = 3<br>P = 0<br>Tut = 1 |
| Physics GE 10 | Quantum Information | T = 3<br>P = 0<br>Tut = 1 |

| GENERIC ELECTIVE COURSE (4 Credits each) | | |
|---|---|---|
| **COURSE CODE** | **NAME OF THE COURSE** | **CREDITS**<br>**T = Theory Credits**<br>**P = Practical Credits**<br>**Tut = Tutorial Credits** |
| **POOL B**<br><br>**(TO BE OFFERED IN SEMESTERS 2/4/6/8)** | | |
| Physics GE 11 | Electricity and Magnetism | T = 3<br>P = 1<br>Tut = 0 |
| Physics GE 12 | Thermal Physics | T = 3<br>P = 1<br>Tut = 0 |
| Physics GE 13 | Modern Physics | T = 3<br>P = 1<br>Tut = 0 |
| Physics GE 14 | Introductory Astronomy | T = 3<br>P = 0<br>Tut = 1 |
| Physics GE 15 | Quantum Mechanics | T = 3<br>P = 0<br>Tut = 1 |
| Physics GE 16 | Introduction to Embedded System Design | T = 2<br>P = 2<br>Tut = 0 |
| Physics GE 17 | Nano Physics | T = 2<br>P = 2<br>Tut = 0 |
| Physics GE 18 | Physics of Detectors | T = 3<br>P = 0<br>Tut = 1 |
| Physics GE 19 | Nuclear and Particle Physics | T = 3<br>P = 0<br>Tut = 1 |
| Physics GE 20 | Atomic and Molecular Physics | T = 3<br>P = 0<br>Tut = 1 |

The Physics GE courses will be offered in Pool.
**Physics GE 1 to GE 10** constitutes **Pool A** and should be offered in **ODD** semester.
**Physics GE 11 to GE 20** constitutes **Pool B** and should be offered in **EVEN** semester.

## 8. Teaching-Learning Process

The undergraduate programme in Physical Sciences is designed to provide students with a sound theoretical background, practical training in all aspects of Physical Sciences and research. It will help them develop an appreciation of the importance of Physical Sciences in different contexts. The programme includes foundational as well as in-depth courses that span the interdisciplinary approach in Physical Sciences. Along with the above core courses there are DSEs, GEs, SECs, AECs and VACs which address the need of the hour. The pre-requisite for this programme is CUET UG entrance exam syllabus.

These courses will be delivered through the conventional chalk and talk method, laboratory work, projects, case studies, field work, seminars, hands-on training/workshops in a challenging, engaging, and inclusive manner that accommodates a variety of learning styles and ICT enabled teaching-learning tools (PowerPoint presentations, audio visual resources, e-resources, models, softwares, simulations, virtual labs etc).

Students will be encouraged to carry out short term projects and participate in industrial and institutional visits and outreach programmes. They will be introduced to scientific reasoning and discovery, innovative problem-solving methodologies, online quizzes, surveys, critical analysis etc. to develop convergent and divergent thinking abilities.

The laboratory training complements the theoretical principles learned in the classroom and includes hands-on experience with modern instruments, computational data analysis, modelling, error estimation and laboratory safety procedures.

Different pedagogies such as experiential learning, participative learning, project-based learning, inquiry-based learning, peer-led instruction and ICT pedagogy integration instruction (blended and flipped learning) will be adopted wherever possible. Students will be encouraged to work in groups to develop their interpersonal skills like communication and team work.

Students' diligent and active participation/ engagement in industrial visits/ internships/ Academic Projects/ Dissertations will lay a strong foundation for a successful career in academics, industry, research, entrepreneurship and community outreach.

## 9. Assessment Methods

The primary objective of assessment will be to assess the learning outcomes of the course in tune with the broad outcomes of strengthening core theoretical knowledge base, practical laboratory skills, and research. Assessment will be based on continuous evaluation (class test, presentation, group discussion, quiz, assignment etc.) and end of semester examination of University of Delhi.

**(i) Internal Assessment or Continuous Evaluation:** During a semester, students' mastery of the various learning outcomes as described in the syllabus will be assessed through class tests, assignments, group assignments, laboratory record files, project reports, quizzes, MCQs, presentations etc. Each theory paper will have 25% marks for internal assessment. The component of internal assessment for each practical paper will be 50% marks. The critical analysis of internal assessment/ continuous evaluation outcomes will provide opportunities to improve the teaching-learning process by focusing on the areas that need conceptual strengthening, laboratory exposure or design of new experiments, and research.

**(ii) End of Semester University Examinations:** The summative end-semester Delhi University examinations will be conducted for both theory and practical courses. Each theory paper will have 75% marks and each practical paper will be of 50% marks for end of semester examination of the University.

## 10. Scheme of Examination

A four credit course has a total of 100 marks and a two credit course is of 50 marks. The distribution of 100 marks for each of DSC (4T+0P and 2T+2P), DSE (4T+0P, 2T+2P, 3T+1Tut) and GE (2T+2P+0Tut, 3T+1P+0Tut and 3T+0P+1Tut) courses is shown in **Table 7**. Further, the distribution of 50 marks for each of SEC course in 0T+2P /1T+1P format is also given in Table 7.

**Table 7**

**Distribution of total marks for DSC/DSE/SEC/GE courses in different credit formats.**

| Type of Paper | Credit Format | Theory Component | Practical Component |
|---|---|---|---|
| **Discipline Specific Core (DSC)** | **4 T + 0 P** | **Theory: 100 Marks**<br><br>**Internal assessment:** 25 Marks<br>a) Class Test: 10 Marks<br>b) Assignment/Presentation/Quiz/Group Discussion: 10 Marks<br>c) Attendance: 05 Marks<br><br>**End Semester Theory Examination:** 75 Marks | NA |
| **Discipline Specific Core (DSC)** | **2 T + 2 P** | **Theory: 50 Marks**<br><br>**Internal assessment:** 12 Marks:<br>a) Class Test: 05 Marks<br>b) Assignment/presentation/Quiz/Group discussion: 05 Marks<br>c) Attendance: 02 Marks<br><br>**End Semester Theory Examination:** 38 Marks | **Practical: 50 Marks**<br><br>**Practical Examination:** 25 Marks:<br>a) Experiment: 20 Marks<br>b) Viva Voce/ Written Test: 05 Marks<br><br>**Continuous Evaluation:** 25 Marks<br>a) Performance Assessment: 15 Marks<br>b) Record File: 10 Marks |
| **Discipline Specific Elective (DSE)** | **4 T + 0 P** | **Theory: 100 Marks**<br><br>**Internal assessment:** 25 Marks<br>a) Class Test: 10 Marks<br>b) Assignment/Presentation/Quiz/Group Discussion: 10 Marks<br>c) Attendance: 05 Marks<br><br>**End Semester Theory Examination:** 75 Marks | NA |

| Type of Paper | Credit Format | Theory Component | Practical Component |
|---|---|---|---|
| **Discipline Specific Elective (DSE)** | **2 T + 2 P** | **Theory: 50 Marks**<br><br>**Internal assessment:** 12 Marks:<br>a) Class Test: 05 Marks<br>b) Assignment/presentation/Quiz/Group discussion: 05 Marks<br>c) Attendance: 02 Marks<br><br>**End Semester Theory Examination:** 38 Marks | **Practical: 50 Marks**<br><br>**Practical Examination:** 25 Marks:<br>a) Experiment: 20 Marks<br>b) Viva Voce/ Written Test: 05 Marks<br><br>**Continuous Evaluation:** 25 Marks<br>a) Performance Assessment: 15 Marks<br>b) Record File: 10 Marks |
| **Discipline Specific Elective (DSE)** | **3T + 0P + 1Tut** | **Theory: 100 Marks**<br><br>**Internal assessment:** 25 Marks<br>a) Class Test: 10 Marks<br>b) Assignment/Presentation/Quiz/Group Discussion: 10 Marks<br>c) Attendance: 05 Marks<br><br>**End Semester Theory Examination:** 75 Marks | NA |
| **Skill Enhancement Course (SEC)** | **0 T + 2 P** | NA | **Practical: 50 Marks**<br><br>**Practical Examination:** 25 Marks:<br>a) Experiment: 20 Marks<br>b) Viva Voce/ Written Test: 05 Marks<br><br>**Continuous Evaluation:** 25 Marks<br>a) Performance Assessment: 15 Marks<br>b) Record File: 10 Marks |
| **Skill Enhancement Course (SEC)** | **1 T + 1 P** | **Theory: 25 Marks**<br><br>**Internal assessment:** 06 Marks:<br>a) Class Test: 2.5 Marks<br>b) Assignment/presentation/Quiz/Group Discussion: 2.5 Marks<br>c) Attendance: 1 Marks<br><br>**End Semester Theory Examination:** 19 Marks | **Practical: 25 Marks**<br><br>**Practical Examination:** 12.5 Marks:<br>a) Experiment: 10 Marks<br>b) Viva Voce: 2.5 Marks<br><br>**Continuous Evaluation:** 12.5 Marks:<br>a) Performance Assessment: 7.5 Marks<br>b) Record File: 5 Marks |
| **Generic Elective (GE)** | **2 T + 2 P** | **Theory: 50 Marks**<br><br>**Internal assessment:** 12 Marks<br>a) Class Test: 05 Marks<br>b) Assignment/Presentation/Quiz/Group Discussion: 05 Marks<br>c) Attendance: 02 Marks<br><br>**End Semester Theory Examination:** 38 Marks | **Practical: 50 Marks**<br><br>**Practical Examination:** 25 Marks<br>a) Experiment: 20 Marks<br>b) Viva Voce: 05 Marks<br><br>**Continuous Evaluation:** 25 Marks<br>a) Performance Assessment: 15 Marks<br>b) Record File: 10 Marks |

| Type of Paper | Credit Format | Theory Component | Practical Component |
|---|---|---|---|
| **Generic Elective (GE)** | **3T + 1P + 0Tut** | **Theory: 75 Marks**<br><br>**Internal assessment:** 25 Marks<br>a) Class Test: 10 Marks<br>b) Assignment/Presentation/Quiz/Group Discussion: 10 Marks<br>c) Attendance: 05 Marks<br><br>**End Semester Theory Examination:** 50 Marks | **Practical: 25 Marks**<br><br>**Practical Examination:** 12.5 Marks:<br>a) Experiment: 10 Marks<br>b) Viva Voce: 2.5 Marks<br><br>**Continuous Evaluation:** 12.5 Marks:<br>a) Performance Assessment: 7.5 Marks<br>b) Record File: 5 Marks |
| **Generic Elective (GE)** | 3T + 0P + 1Tut | **Theory: 100 Marks**<br><br>**Internal assessment:** 25 Marks<br>a) Class Test: 10 Marks<br>b) Assignment/Presentation/Quiz/Group Discussion: 10 Marks<br>c) Attendance: 05 Marks<br><br>**End Semester Theory Examination:** 75 Marks | NA |

### Minimum Acceptable Level of Academic Standards

The minimum acceptable level of achievement that a student must demonstrate to be eligible for the award of academic credit or a qualification is the minimum acceptable level of academic standards. The Letter Grades and Grade Points which shall be used to reflect the outcome of assessment process of the student's performance is indicated in **Table 8**.

**TABLE 8**
**Letter Grades and Grade Points**

| Letter Grade | Grade Point |
|---|---|
| O (outstanding) | 10 |
| A+ (Excellent) | 9 |
| A (Very good) | 8 |
| B+ (Good) | 7 |
| B (Above average) | 6 |
| C (Average) | 5 |
| P (Pass) | 4 |
| F (Fail) | 0 |
| AB (Absent) | 0 |

## Computation of the grade cut-offs on a 10-point grading system

The results for all the Undergraduate courses under the UGCF 2022 shall be based on a 10 point grading system with Letter Grades as per the formula prescribed in amendment to Ordinance IX clause 12(3) dated 08th May, 2017 of the University of Delhi in the computation of the grade cut offs as shown in **Table 9**.

**Table 9**

**The computation of the grade cut-offs on a 10 point grading system with Letter Grades**

| Letter Grade | Numerical Grade | Formula | Computation of Grade Cut off |
|---|---|---|---|
| O (Outstanding) | 10 | $m \geq \bar{X} + 2.5\ \sigma$ | the value of $\bar{X}$ + 2.5 σ a to be taken into account for grade computation will be Actual $\bar{X}$ + 2.5 σ or 90% whichever is lower |
| A+ (Excellent) | 9 | $\bar{X} + 2.0\ \sigma \leq m < \bar{X} + 2.5\ \sigma$ | the value of $\bar{X}$ + 2.0 σ a to be taken into account for grade computation will be Actual $\bar{X}$ + 2.0 σ or 80% whichever is lower |
| A (Very Good) | 8 | $\bar{X} + 1.5\ \sigma \leq m < \bar{X} + 2.0\ \sigma$ | the value of $\bar{X}$ + 1.5 σ a to be taken into account form grade computation will be Actual $\bar{X}$ + 1.5 σ or 70% whichever is lower |
| B+ (Good) | 7 | $\bar{X} + 1.0\ \sigma \leq m < \bar{X} + 1.5\ \sigma$ | the value of $\bar{X}$ + 1.0 σ a to be taken into account for grade computation will be Actual $\bar{X}$ + 1.0 σ or 60% whichever is lower |
| B (Above average) | 6 | $\bar{X} \leq m < \bar{X} + 1.0\ \sigma$ | the value of $\bar{X}$ a to be taken into account for grade computation will be Actual $\bar{X}$ or 50% whichever is lower |
| C (Average) | 5 | $\bar{X} - 0.5\ \sigma \leq m < \bar{X}$ | the value of $\bar{X}$ - 0.5 σ a to be taken into account for grade computation will be Actual $\bar{X}$ - 0.5 σ or 40% whichever is lower |
| D (Pass) | 4 | $\bar{X} - \sigma \leq m < \bar{X} - 0.5\ \sigma$ | the value of $\bar{X}$ - 1.0 σ a to be taken into account for grade computation will be Actual $\bar{X}$ - 1.0 σ or 30% whichever is lower |

*m* is the marks obtained by a student in a particular paper in that semester.

$\bar{X}$ is the average of marks obtained by all the students appeared in that particular paper in that semester.

σ is the standard deviation.

# DISCIPLINE SPECIFIC CORE (DSC) COURSES

## SEMESTER I

**Course Code: PHYSICS DSC 1**

**Course Title: MECHANICS**

**Total Credits: 04 (Credits: Theory: 02, Practical: 02)**

**Total Hours: Theory: 30, Practical: 60**

**Course Objectives:** 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 dynamics of a system of particles and ends with the special theory of relativity. Students will appreciate the concept of 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.

- Laws of motion and their application to various dynamical situations.
- Conservation of momentum, angular momentum and energy. Their application to basic problems.
- Particle collision (elastic and in-elastic collisions)
- Motion of simple pendulum
- Postulates of special theory of relativity, inertial and non-inertial frame of reference and their transformation, relativistic effects on the mass and energy of a moving body.

In the laboratory course, after acquiring knowledge of how to handle measuring instruments (like screw gauge, vernier calliper and travelling microscope) student shall embark on verifying various principles and associated measurable quantities.

### THEORY (Credit: 02; 30 Hours)

**Unit 1: Review of vectors and ordinary differential equation** **Hours: 4**

Gradient of a scalar field, divergence and curl of vectors field, polar and axial vectors
Second order homogeneous ordinary differential equations with constant coefficients (Operator Method Only).

**Unit 2: Fundamentals of Dynamics** **Hours: 7**

Dynamics of a system of particles, centre of mass, determination of centre of mass for discrete and continuous systems having spherical symmetry

Conservation of momentum and energy, Conservative and non-Conservative forces, work – energy theorem for conservative forces, force as a gradient of potential energy. Particle collision (Elastic and in-elastic collisions)

**Unit 3: Rotational Dynamics and Oscillatory Motion** **Hours: 8**

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 and 2-D).

Idea of simple harmonic motion, differential equation of simple harmonic motion and its solution, Motion of simple pendulum, damped harmonic oscillator

**Unit 4: Gravitation** **Hours: 3**

Newton's Law of Gravitation, Motion of a particle in a central force field. Kepler's Laws (statements only).

**Unit 5: Special Theory of Relativity** **Hours: 8**

Frames of reference, Gallilean transformations, inertial and non-inertial frames, Michelson Morley's Experiment, postulates of special theory of relativity, length contraction, time dilation, relativistic transformation of velocity, relativistic variation of mass.

**References:**

**Essential Readings:**


1) Vector Analysis – Schaum's Outline, M.R. Spiegel, S. Lipschutz, D. Spellman, 2$^{nd}$ Edn., 2009, McGraw Hill Education.
2) An Introduction to Mechanics (2/e), Daniel Kleppner and Robert Kolenkow, 2014, Cambridge University Press.
3) Mechanics Berkeley Physics Course, Vol. 1, 2/e: Charles Kittel, et. al., 2017, McGraw Hill Education
4) Mechanics, D. S. Mathur, P. S. Hemne, 2012, S. Chand.
5) Intermediate Dynamics, Patrick Hamill, 2010, Jones and Bartlett Publishers.


**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 and 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.

## PRACTICAL (Credit: 02; 60 Hours)

The teacher is expected to give basic idea and working of various apparatus and instruments related to different experiments. Students should also be given knowledge of recording and analysing experimental data.

Every student should perform at least 06 experiments from the following list.

1) Measurement of length (or diameter) using vernier calliper, screw gauge and travelling microscope.
2) Study the random error in observations.
3) Determination of height of a building using a sextant.
4) Study of motion of the spring and calculate (a) spring constant and, (b) acceleration due to gravity (g)
5) Determination of moment of inertia of a flywheel.
6) Determination of g and velocity for a freely falling body using digital timing technique.
7) Determination of modulus of rigidity of a wire using Maxwell's needle.
8) Determination of elastic constants of a wire by Searle's method.
9) Determination of value of g using bar pendulum.
10) Determination of value of g using Kater's pendulum.

### References:


**1)** Advanced practical physics for students, B. L. Flint and H. T. Worsnop, 1971, Asia Publishing House.

**2)** Engineering practical physics, S. Panigrahi and 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 and Ramakrishna, 11/e, 2011, Kitab Mahal.

**5)** B. Sc. practical physics, Geeta Sanon, R. Chand and Co., 2016.

**Course Code: PHYSICS DSC 2**

**Course Title: NETWORK ANALYSIS AND ANALOG ELECTRONICS**

**Total Credits: 04 (Credits: Theory: 02, Practical: 02)**

**Total Hours: Theory: 30, Practical: 60**

**Course Objectives:**

- 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 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 in case of Oscillators.
- To become familiar with construction, working and characteristics of JFET and UJT.

---

## THEORY (Credit: 02; 30 Hours)

**Unit 1:** **Hours: 8**

Circuit Analysis: Concept of Voltage and Current Sources (ideal and practical). Kirchhoff's Laws. Mesh Analysis, Node Analysis. Star and Delta networks and their Conversion.

Superposition Theorem. Thevenin's Theorem. Norton's Theorem. Reciprocity Theorem. Maximum Power Transfer Theorem.

**Unit 2:** **Hours: 5**

**Semiconductor Diode:** PN junction diode (Ideal and practical), Diode equation (Qualitative only) and I-V characteristics. Idea of static and dynamic resistance, Zener diode working.
**Rectifiers**: Half wave rectifier (Qualitative only), Full wave rectifiers (center tapped and bridge): circuit diagrams, working and waveforms, ripple factor and efficiency.
**Filter circuits**: Shunt capacitance and series Inductance filter (no derivation).
**Regulation**: Zener diode as voltage regulator for load and line regulation

**Unit 3:** **Hours: 7**

**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.
**Amplifiers:** Transistor biasing and Stabilization circuits- Voltage Divider Bias. Thermal runaway, stability (Qualitative only). 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.

**Unit 4:** **Hours: 10**

**Cascaded Amplifiers:** Two stage RC Coupled Amplifier and its frequency response.
**Sinusoidal Oscillators:** Concept of feedback (negative and positive feedback), Barkhausen criterion for sustained oscillations. Phase shift and Colpitt's oscillator. Determination of frequency and condition of oscillation
**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. UJT Oscillator.

### References:

### Essential Readings:


1) Network, Lines and Fields, J. D. Ryder, Prentice Hall of India
2) Integrated Electronics, J. Millman and C.C. Halkias, Tata Mcgraw Hill (2001)
3) Electric Circuits , S. A. Nasar, Schaum Outline Series, Tata McGraw Hill (2004)
4) Electric Circuits, K.A. Smith and R. E. Alley, Cambridge University Press(2014)
5) 2000 Solved Problems in Electronics, J. J. Cathey, Schaum Outline Series, Tata McGraw Hill (1991)


### Additional Readings:


1) Microelectronic Circuit, A. S. Sedra, K.C. Smith, A. N. Chandorkar, 6th Edition (2014), Oxford University Press
2) Electronic Circuits: Discreet and Integrated, D. L. Schilling and C. Belove, Tata McGraw Hill.

**3)** Electronic Devices and Circuits, David A. Bell, 5th Edition 2015, Oxford University Press.
**4)** Electrical Circuits, M. Nahvi and J. Edminister, Schaum Outline Series, Tata McGraw Hill (2005)

## PRACTICAL (Credit: 02; 60 Hours)

At least 06 experiments from the following:

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

## References (For Laboratory Work):

**1)** Electronic Devices and Circuits, Allen Mottershead, Goodyear Publishing Corporation.
**2)** Electrical Circuits, M. Nahvi and J. Edminister, Schaum Outline Series, Tata McGraw Hill (2005)
**3)** Network, Lines and Fields, J. D. Ryder, Prentice Hall of India
**4)** Integrated Electronics, J. Millman and C.C. Halkias, Tata Mcgraw Hill (2001)

# SEMESTER II

**Course Code: PHYSICS DSC 3**

**Course Title: ELECTRICITY AND MAGNETISM**

**Total Credits: 04 (Credits: Theory: 02, Practical: 02)**

**Total Hours: Theory: 30, Practical: 60**

**Course Objectives:** This course reviews the concepts of electricity and magnetism 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,

- Understand Gauss' law, Coulomb's law for the electric field, and apply them to systems of point charges as well as line, surface, and volume distributions of charges. Also to use the knowledge to solve some simple problems
- Express electric current and capacitance in terms of electric field and electric potential.
- Calculate the force experienced by a moving charge in a magnetic field
- To determine the magnetic force generated by a current carrying conductor
- Have brief idea of magnetic materials, understand the concept of electromagnetic induction, solve problems using Faraday's and Lenz's laws

In the laboratory 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 electric circuits.

## THEORY (Credit: 02; 30 Hours)

**Unit 1: Electrostatics** **Hours: 10**

Electric field, electric flux, Gauss' theorem in electrostatics, applications of Gauss' theorem (linear, plane and spherical charge distribution), line integral of electric field, electric potential due to a point charge, electric potential and electric field of a dipole and charged disc, capacitance due to parallel plates and spherical condenser. Electrostatic energy of system of charge (charged sphere), dielectric medium, dielectric polarization, displacement vector, Gauss' theorem in dielectrics, parallel plate capacitor filled with dielectric.

**Unit 2: Magnetostatics** **Hours: 8**

Magnetic force between current elements and definition of magnetic field B, Biot-Savart's law and its applications (current carrying straight conductor, current carrying circular coil, current carrying solenoid), divergence and curl of magnetic field, Ampere's circuital law, magnetic properties of materials (magnetic intensity, magnetic induction, permeability, magnetic susceptibility), brief introduction of dia-, para- and ferro magnetic materials

**Unit 3: Electromagnetic Induction** **Hours: 7**

Faraday's laws of electromagnetic induction, Lenz's law, self-inductance of single coil, mutual inductance of two coils, energy stored in magnetic field. Maxwell`s equations and equation of continuity of current, displacement current

**Unit 4: Electrical Circuits** **Hours: 5**

DC Circuits: Review of Kirchhoff's Voltage and Current Laws, Thevenin theorem, Norton theorem, Superposition theorem, Maximum Power Transfer theorem.

**References:**

**Essential Readings:**


1) Fundamentals of Electricity and Magnetism, Arthur F. Kip, 2nd Edn.1981, McGraw-Hill.
2) Electricity and Magnetism, J.H. Fewkes and 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) Introduction to Electrodynamics, D.J. Griffiths, 3rd Edn, 1998, Benjamin Cummings.


**Additional Readings:**


1) Electricity and Magnetism, Berkeley Physics Course, Edward M. Purcell, 1986, McGraw-Hill Education.
2) University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.
3) Problems and Solutions in Electromagnetics, Ajoy Ghatak, K Thyagarajan and Ravi Varshney.
4) Schaum's Outline of Electric Circuits, J. Edminister and M. Nahvi, 3rd Edn., 1995, McGraw Hill.


**PRACTICAL (Credit: 02; 60 Hours)**

The teacher is expected to give basic idea and working of various instruments and circuits related to different experiments. Students should also be given knowledge of recording and analyzing experimental data.

Every student should perform at least 06 experiments from the following list of experiments.

1) To use a multimeter for measuring resistances, a.c and d.c voltages, d.c. current, capacitance and for checking electrical fuses.

2) Ballistic Galvanometer:
    a) Measurement of charge and current sensitivity
    b) Measurement of critical damping resistance
    c) Determine a high resistance by leakage method
    d) 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 and its variation in a Solenoid
5) To study the Characteristics of a Series RC Circuit.
6) To study a series LCR circuit and determine its resonant frequency and quality factor.
7) To study a parallel LCR circuit and determine its anti-resonant frequency and quality factor
8) To determine a low resistance by Carey Foster bridge.
9) To verify the Thevenin, superposition and maximum power transfer theorems
10) To verify Norton theorem

**References (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 and 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

**5)** Advanced level physics practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers

**Course Code: PHYSICS DSC 4**

**Course Title: LINEAR AND DIGITAL INTEGRATED CIRCUITS**

**Total Credits: 04 (Credits: Theory: 02, Practical: 02)**

**Total Hours: Theory: 30, Practical: 60**

**Course Objectives:**

- This paper aims to provide the basic knowledge of linear and digital electronics.
- It discusses about the operational amplifier and its applications.
- 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 Logic Gates and 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.

**THEORY (Credit: 02; 30 Hours)**

---

**Unit 1:** **Hours: 8**

**Operational Amplifiers (Black box approach):** Characteristics of an ideal and practical Operational Amplifier (IC 741), Open and closed loop configuration, CMRR, Slew Rate and the concept of Virtual Ground.

**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 (7) Active low pass and high pass Butter worth filter (1st order only).

**Unit 2:** **Hours: 6**

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

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

**Unit 3:** **Hours: 6**

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

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

**Unit 4:** **Hours: 5**

**Sequential Circuits:** SR, D, and JK Flip-Flops. Race-around conditions in JK Flip-Flop. Master-slave JK Flip-Flop.

**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). Ring Counter.

**Unit 5:** **Hours: 5**

**Counters (4 bits):** Asynchronous counter, Synchronous Counter.

**D-A and A-D Conversion**: 4 bit binary weighted and R-2R D-A converters, A-D conversion characteristics, successive approximation ADC.

**References:**

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


## PRACTICAL (Credit: 02; 60 Hours)

Every student should perform at least 04 experiments each from section A, B and C

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

1) To design an inverting and non-inverting amplifier using Op-amp (741,351) for dc voltage of given gain.
2) To design inverting and non-inverting amplifier using Op-amp (741,351) and study their frequency responses
3) To add two dc voltages using Op-Amp in inverting and non-inverting mode.
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) Design a Butter-worth Low Pass active Filter (1st order) and study frequency response.

9) Design a Butter-worth High Pass active Filter (1st order) and study frequency response.
10) 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, 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.

**References (For Laboratory Work):**


**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.

# SEMESTER III

**Course Code: PHYSICS DSC 5**

**Course Title: THERMAL PHYSICS**

**Total Credits: 04 (Credits: Theory: 02, Practical: 02)**

**Total Hours: Theory: 30, Practical: 60**

**Syllabus to be prepared later**

**Course Code: PHYSICS DSC 6**

**Course Title: COMMUNICATION ELECTRONICS**

**Total Credits: 04 (Credits: Theory: 02, Practical: 02)**

**Total Hours: Theory: 30, Practical: 60**

**Syllabus to be prepared later**

# SEMESTER IV

**Course Code: PHYSICS DSC 7**

**Course Title: WAVES AND OPTICS**

**Total Credits: 04 (Credits: Theory: 02, Practical: 02)**

**Total Hours: Theory: 30, Practical: 60**

**Syllabus to be prepared later**

**Course Code: PHYSICS DSC 8**

**Course Title: MICROPROCESSOR AND MICROCONTROLLER**

**Total Credits: 04 (Credits: Theory: 02, Practical: 02)**

**Total Hours: Theory: 30, Practical: 60**

**Syllabus to be prepared later**

# SEMESTER V

**Course Code: PHYSICS DSC 9**

**Course Title: MODERN PHYSICS**

**Total Credits: 04 (Credits: Theory: 02, Practical: 02)**

**Total Hours: Theory: 30, Practical: 60**

**Syllabus to be prepared later**

# SEMESTER VI

**Course Code: PHYSICS DSC 10**

**Course Title: SOLID STATE PHYSICS**

**Total Credits: 04 (Credits: Theory: 02, Practical: 02)**

**Total Hours: Theory: 30, Practical: 60**

**Syllabus to be prepared later**

# SEMESTER VII

**Course Code: PHYSICS DSC 11**

**Course Title: QUANTUM MECHANICS**

**Total Credits: 04 (Credits: Theory: 04, Practical: 00)**

**Total Hours: Theory: 60, Practical: 00**

**Syllabus to be prepared later**

# SEMESTER VIII

**Course Code: PHYSICS DSC 12**

**Course Title: ELECTROMAGNETIC THEORY**

**Total Credits: 04 (Credits: Theory: 04, Practical: 00)**

**Total Hours: Theory: 60, Practical: 00**

**Syllabus to be prepared later**

# DISCIPLINE SPECIFIC ELECTIVE (DSE) COURSES

## SEMESTER III

**Course Code: PHYSICS DSE 1**

**Course Title: BIOPHYSICS**

**Total Credits: 04 (Credits: Theory: 04, Practical: 00)**

**Total Hours: Theory: 60, Practical: 00**

**Syllabus to be prepared later**

**Course Code: PHYSICS DSE 2**

**Course Title: MATHEMATICAL PHYSICS I**

**Total Credits: 04 (Credits: Theory: 04, Practical: 00)**

**Total Hours: Theory: 60, Practical: 00**

**Syllabus to be prepared later**

# SEMESTER IV

**Course Code: PHYSICS DSE 11**

**Course Title: NUMERICAL ANALYSIS**

**Total Credits: 04 (Credits: Theory: 02, Practical: 02)**

**Total Hours: Theory: 30, Practical: 60**

**Syllabus to be prepared later**

**Course Code: PHYSICS DSE 12**

**Course Title: PHYSICS OF EARTH**

**Total Credits: 04 (Credits: Theory: 04, Practical: 00)**

**Total Hours: Theory: 60, Practical: 00**

**Syllabus to be prepared later**

# SEMESTER V

**Course Code: PHYSICS DSE 3**

**Course Title: SEMICONDUCTOR DEVICES FABRICATION**

**Total Credits: 04 (Credits: Theory: 02, Practical: 02)**

**Total Hours: Theory: 30, Practical: 60**

**Syllabus to be prepared later**

**Course Code: PHYSICS DSE 4**

**Course Title: ELECTRONICS INSTRUMENTATION**

**Total Credits: 04 (Credits: Theory: 02, Practical: 02)**

**Total Hours: Theory: 30, Practical: 60**

**Syllabus to be prepared later**

**Course Code: PHYSICS DSE 5**

**Course Title: DIGITAL SIGNAL PROCESSING**

**Total Credits: 04 (Credits: Theory: 02, Practical: 02)**

**Total Hours: Theory: 30, Practical: 60**

**Syllabus to be prepared later**

# SEMESTER VI

**Course Code: PHYSICS DSE 13**

**Course Title: RESEARCH METHODOLOGY**

**Total Credits: 04 (Credits: Theory: 04, Practical: 00)**

**Total Hours: Theory: 60, Practical: 00**

**Syllabus to be prepared later**

**Course Code: PHYSICS DSE 14**

**Course Title: Verilog and FPGA based System Design**

**Total Credits: 04 (Credits: Theory: 02, Practical: 02)**

**Total Hours: Theory: 30, Practical: 60**

**Syllabus to be prepared later**

**Course Code: PHYSICS DSE 15**

**Course Title: PHOTONICS DEVICES AND POWER ELECTRONICS**

**Total Credits: 04 (Credits: Theory: 02, Practical: 02)**

**Total Hours: Theory: 30, Practical: 60**

**Syllabus to be prepared later**

**Course Code: PHYSICS DSE 16**

**Course Title: ANTENNA THEORY AND WIRELESS NETWORK**

**Total Credits: 04 (Credits: Theory: 02, Practical: 02)**

**Total Hours: Theory: 30, Practical: 60**

**Syllabus to be prepared later**

## SEMESTER VII

**Course Code: PHYSICS DSE 6**

**Course Title: PHYSICS OF MATERIALS**

**Total Credits: 04 (Credits: Theory: 02, Practical: 02)**

**Total Hours: Theory: 30, Practical: 60**

**Syllabus to be prepared later**

**Course Code: PHYSICS DSE 7**

**Course Title: INTRODUCTION TO ATOMIC AND MOLECULAR PHYSICS**

**Total Credits: 04 (Credits: Theory: 04, Practical: 00)**

**Total Hours: Theory: 60, Practical: 00**

## Syllabus to be prepared later

**Course Code: PHYSICS DSE 8**

**Course Title: CLASSICAL DYNAMICS**

**Total Credits: 04 (Credits: Theory: 03, Practical: 00, Tutorial: 01)**

**Total Hours: Theory: 45, Practical: 00, Tutorial: 15**

**Syllabus to be prepared later**

**Course Code: PHYSICS DSE 9**

**Course Title: SENSORS AND DETECTORS**

**Total Credits: 04 (Credits: Theory: 02, Practical: 02)**

**Total Hours: Theory: 30, Practical: 60**

**Syllabus to be prepared later**

**Course Code: PHYSICS DSE 10**

**Course Title: RESEARCH METHODOLOGY**

**Total Credits: 04 (Credits: Theory: 04, Practical: 00)**

**Total Hours: Theory: 60, Practical: 00**

**Syllabus to be prepared later**

## SEMESTER VIII

**Course Code: PHYSICS DSE 17**

**Course Title: NANO SCIENCE**

**Total Credits: 04 (Credits: Theory: 02, Practical: 02)**

**Total Hours: Theory: 30, Practical: 60**

**Syllabus to be prepared later**

**Course Code: PHYSICS DSE 18**

**Course Title: NUCLEAR AND PARTICLE PHYSICS**

**Total Credits: 04 (Credits: Theory: 04, Practical: 00)**

**Total Hours: Theory: 60, Practical: 00**

**Syllabus to be prepared later**

**Course Code: PHYSICS DSE 19**

**Course Title: STATISTICAL PHYSICS**

**Total Credits: 04 (Credits: Theory: 04, Practical: 00)**

**Total Hours: Theory: 60, Practical: 00**

**Syllabus to be prepared later**

**Course Code: PHYSICS DSE 20**

**Course Title: PHYSICS OF ATMOSPHERE AND CLIMATE CHANGE**

**Total Credits: 04 (Credits: Theory: 03, Practical: 01)**

**Total Hours: Theory: 45, Practical: 30**

**Syllabus to be prepared later**

# SKILL ENHANCEMENT COURSES (SEC)

**Note: These are suggestive SEC courses. A student may however choose any SEC from the central pool of Physics/Electronics/Mathematics**

**Course Code: PHYSICS SEC 1**

**Course Title: BASIC OF INSTRUMENTS**

**Total Credits: 02 (Credits: Theory: 00, Practical: 02)**

**Total Hours: Theory: 00, Practical: 60**

**Course Objectives:** 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, multivibrators, rectifiers, amplifiers, oscillators and high voltage probes and their significance with hands on mode.
- Explanation 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 digital multimeter and frequency counter.

---

## PRACTICAL (Credit: 02; 60 Hours)

The list of experiments for this course is based on the following topics.

- **Basics of Measurement:** Instruments accuracy, precision, sensitivity, resolution range etc. Errors in measurements and loading effects. Working principle of time interval, frequency and period measurement, time-base stability, accuracy and resolution.
- **Multimeter:** Measurement of dc voltage and dc current, ac voltage, ac current and resistance. Specifications of electronic voltmeter/multimeter and their significance. AC milli-voltmeter, working of a digital multimeter.
- **Cathode Ray Oscilloscope:** Specifications of CRO with block diagram and their significance. Measurement of voltage (dc and ac), frequency and time period. Special features of dual trace. Digital storage Oscilloscope: principle of working.
- **Signal and Pulse Generators:** Block diagram and specifications of low frequency signal and pulse generators. Distortion factor meter, wave analysis.
- **Impedance Bridges:** Block diagram, working principles of RLC Bridge. Specifications of RLC Bridge. Block diagram and working principles of a Q-Meter. Digital LCR bridges.

**List of Experiments:**

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 Q-meter.
4) Measurement of voltage, frequency, time period and phase using an oscilloscope.
5) Measurement of time period, frequency, average period using universal counter/frequency counter.
6) Measurement of rise, fall and delay times using oscilloscope.
7) Measurement of distortion of a RF signal generator using distortion factor meter.
8) Measurement of R, L and C using 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 experiments enumerated above.

**References:**

**Essential Readings:**


**1)** Logic circuit design, Shimon P. Vingron, 2012, Springer.
**2)** Digital Electronics, Subrata Ghoshal, 2012, Cengage Learning.
**3)** Electronic Devices and circuits, S. Salivahanan and N. S. Kumar, 3rd Ed., 2012, Tata Mc-Graw Hill
**4)** Digital Circuits and Systems, Venugopal, 2011, Tata McGraw Hill.
**5)** Electronic Instrumentation, H.S. Kalsi, 3rd Ed. Tata McGraw Hill.

**Additional Readings:**


**1)** A text book in Electrical Technology - B L Theraja - S Chand and Co.

**2)** Performance and design of AC machines - M G Say ELBS Edn.

**Course Code: PHYSICS SEC 2**

**Course Title: PROGRAMMING FOR PHYSICAL APPLICATIONS (C/C++ OR PYTHON)**

**Total Credits: 02 (Credits: Theory: 00, Practical: 02)**

**Total Hours: Theory: 00, Practical: 60**

**Course Learning Outcomes:** The aim of this course is to teach computer programming and basic idea of numerical analysis, emphasizing its role in solving problems in Physics, and other fields.

- Use computers for solving problems in Physics
- Prepare algorithms and flowcharts for solving a problem.
- Design, code and test simple programs in C/C++ or Python in the process of solving various problems.
- Perform various operations of 1-d and 2-d arrays
- Visualise data and functions graphically

The course will consist of practical sessions including relevant lectures on the related theoretical aspects of the Laboratory.

- Evaluation to be done not only on the programming but also 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 more practice.

## C/C++

1) Basics of scientific computing: Binary and decimal arithmetic, Floating point numbers, single and double precision arithmetic, underflow and overflow, Iterative method. Algorithms and Flow charts: Purpose, symbols and description.
2) Introduction to C++: Introduction to Programming: Algorithms: Sequence, Selection and Repetition, Structured programming, basic idea of Compilers. Idea of Headers, Data Types, Enumerated Data, Conversion and 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. Input and output statements. Reading Input and sending output from/to files.

Programs (indicative only):

- To calculate area of a rectangle
- To check size of variables in bytes (Use of sizeof( ) Operator)
- Converting plane polar to Cartesian coordinates and vice versa

3) 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 (indicative only):

   - To find roots of a quadratic equation
   - To find largest of three numbers
   - To check whether a number is prime or not
   - To list Prime numbers up to 1000

4) Functions and Arrays: Introduction, inbuilt functions, local vs. global variables, function definition and prototype, user-defined functions, void functions, return statement, passing arguments by value, arrays, array definition, passing arrays to functions, 2D arrays, matrix operations (sum, product, transpose etc)

   Programs (indicative only):

   - Sum and average of a list of numbers
   - Largest of a given list of numbers and its location
   - Sorting numbers in ascending descending order using Bubble sort and Sequential sort
   - Binary search
   - Matrix operations (sum, product, transpose etc)
   - Approximate functions like sin(x), cos(x) by a finite number of terms of Taylor's series.

5) Introduction to gnuplot for plotting functions and data for graphical visualization. Curve fitting: Linear least square fitting of data.

   Programs (indicative only):

   - Plotting data from the output file created by a c-program
   - Plotting functions (inbuilt), histograms, and graphs.
   - Overlapping plots
   - Least square fit of data points
   - Generation of pseudo-random numbers using inbuilt functions and plot frequency distribution

**References:**


**1)** Schaum's Outline of Programming with C++', J. Hubbard, 2000, McGraw-Hill Education.

**2)** C++ How to Program', Paul J. Deitel and Harvey Deitel, Pearson (2016).

3) Introduction to Numerical Analysis, S.S. Sastry, 5th Edn., 2012, PHI Learning Pvt. Ltd.
4) Computational Physics, Darren Walker, 1st Edn., Scientific International Pvt. Ltd (2015).
5) Elementary Numerical Analysis, K.E. Atkinson, 3rd Edn., 2007, Wiley India Edition.

## OR

## PYTHON

**Introduction :** Binary and decimal arithmetic, Floating point numbers, single and double precision arithmetic, underflow and overflow, numerical errors of elementary floating point operations, round off and truncation errors with examples.
Introduction to Algorithms and Flow charts. Branching with examples of conditional statements, for and while loops.
**Basic Elements of Python:** The Python interpreter, the print statement, comments, Python as simple calculator, objects and expressions, variables(numeric and sequence types) and assignments, mathematical operators. Help() in Python, Strings, Lists, Tuples and Dictionaries, type conversions, input statement, list methods. List mutability, Formatting in the print statement.
**Control Structures:** Conditional operations, if, if-else, if-elif-else, while and for Loops, indentation, break and continue, List comprehension.
**Functions:** Inbuilt functions, user-defined functions, local and global variables, passing functions, modules, importing modules, math module, making new modules.
**File Handling:** 'r', 'w', 'a' modes, Reading from files and writing into text and csv files. Exception handling with try-except, the with statement.

**List of Programs:**
- To calculate area of a rectangle
- To check size of variables in bytes (Use of sizeof( ) Operator)
- Converting plane polar to Cartesian coordinates and vice versa
- To find roots of a quadratic equation
- To find largest of three numbers
- To check whether a number is prime or not
- To list Prime numbers up to 1000

**Numpy, Pandas and Matplotlib:**
Use of Numpy module to (i) determine max, min, mean, variance, standard deviation of a given array, (i) perform matrix manipulations and (iii) compute scalar, vector and scalar triple product of vectors.
Use matplotlib to (i) plot of functions given in closed form as well as in the form of discrete data and (ii) make histogram (iii) contour maps

**List of Programs:**
- Sum and average of a list of numbers
- Largest of a given list of numbers and its location

- Sorting numbers in ascending descending order using Bubble sort and Sequential sort
- Binary search
- Matrix operations (sum, product, transpose etc)
- Approximate functions like sin(x), cos(x) by a finite number of terms of Taylor's series.
- Plotting data from the output file
- Plotting functions (inbuilt), histograms, and graphs.
- Overlapping plots
- Least square fit of data points
- Generation of pseudo-random numbers using inbuilt functions and plot frequency distribution

**References:**


**1)** Documentation at the Python home page (https://docs.python.org/3/) and the tutorials there (https://docs.python.org/3/tutorial/).

**2)** Computational Physics, Darren Walker, 1st Edn., Scientific International Pvt. Ltd (2015).

**3)** Elementary Numerical Analysis, K. E. Atkinson, 3rd Edn., 2007, Wiley India Edition.

**4)** An Introduction to Computational Physics, T. Pang, Cambridge University Press (2010).

**5)** Introduction to Numerical Analysis, S. S. Sastry, 5th Edn., 2012, PHI Learning Pvt. Ltd.

**6)** Applied numerical analysis, Cutis F. Gerald and P. O. Wheatley, Pearson Education, India

**7)** Numerical Recipes: The art of scientific computing, William H. Press, Saul A. Teukolsky and William Vetterling, Cambridge University Press; 3rd edition

**Course Code: PHYSICS SEC 3**

**Course Title: NUMERICAL TECHNIQUES**

**Total Credits: 02 (Credits: Theory: 00, Practical: 02)**

**Total Hours: Theory: 00, Practical: 60**

**Course Objectives:** The emphasis of course is to equip students with the mathematical tools required in solving problem of interest to physicists and to expose them 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:** The numerical methods given below will be implemented using C/C++ or Python programming language, and hence a basic knowledge of the programming language is desirable. The course will consist of practical sessions including relevant lectures on the following theoretical aspects of the laboratory.

- **Errors and iterative methods:** Truncation and Round-off Errors. Floating Point Computation, Overflow and underflow. Single and Double Precision Arithmetic
- **Solutions of Algebraic and Transcendental Equations:** Fixed point iteration method, Bisection method, Secant Method, Newton Raphson method
- **Interpolation, Numerical Differentiation, and Integration:** Forward and Backward Differences. Symbolic Relation, Newton's Forward and Backward Interpolation Formulas, Integration using Trapezoidal Rule, and Simpson's 1/3 and 3/8 Rules.
- **Solution of Ordinary Differential Equations:** First Order ODE's: solution of Initial Value problems: Euler's Method, Modified Euler's method, Runge-Kutta method
- **Least Square fitting:** Linear least square fit on data points, Linearization of exponential function fitting, Fitting using Polynomial of $n$th degree.

---

## PRACTICAL (Credit: 02; 60 Hours)

Every student must perform at least 08 programs from the following list.

Algebraic and transcendental equation:

a. To find the roots of an algebraic equation by Bisection method.

b. To find the roots of an algebraic equation by Secant method.

c. To find the roots of an algebraic equation by Newton-Raphson method.

d. To find the roots of a transcendental equation by Bisection method.

Interpolation
a. To find the forward difference table from a given set of data values.
b. To find a backward difference table from a given set of data values.

Differentiation
a. To find the first and second derivatives near the beginning of the table of values of (x,y).
b. To find the first and second derivatives near the end of the table of values of (x,y).

Integration
a. To evaluate a definite integral by trapezoidal rule.
b. To evaluate a definite integral by Simpson 1/3 rule.
c. To evaluate a definite integral by Simpson 3/8 rule.

Differential Equations
a. To solve differential equations by Euler's method
b. To solve differential equations by modified Euler's method
c. To solve differential equations by Runge-Kutta method

Curve fitting
a. To fit a straight line to a given set of data values.
b. To fit a polynomial to a given set of data values.
c. To fit an exponential function to a given set of data values.

**References:**


**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)** Schaum's Outline of Programming with C++. J. Hubbard, 2000, McGraw Hill Pub.
**4)** Numerical Recipes in C++: The Art of Scientific Computing, W.H. Press et.al., 2nd Edn., 2013, Cambridge University Press.
**5)** An introduction to Numerical methods in C++, Brian H. Flowers, 2009, Oxford University Press.
**6)** C++ How to Program', Paul J. Deitel and Harvey Deitel, Pearson (2016).
**7)** Documentation at the Python home page (https://docs.python.org/3/) and the tutorials there (https://docs.python.org/3/tutorial/).

**Course Code: PHYSICS SEC 4**

**Course Title: ELECTRIC CIRCUITS AND NETWORKS**

**Total Credits: 02 (Credits: Theory: 00, Practical: 02)**

**Total Hours: Theory: 00, Practical: 60**

**Syllabus to be prepared later**

**Course Code: PHYSICS SEC 5**

**Course Title: SENSORS AND DETECTION TECHNOLOGY**

**Total Credits: 02 (Credits: Theory: 01, Practical: 01)**

**Total Hours: Theory: 15, Practical: 30**

**Syllabus to be prepared later**

**Course Code: PHYSICS SEC 6**

**Course Title: RENEWABLE ENERGY AND ENERGY HARVESTING**

**Total Credits: 02 (Credits: Theory: 01, Practical: 01)**

**Total Hours: Theory: 15, Practical: 30**

**Syllabus to be prepared later**

**Course Code: PHYSICS SEC 7**

**Course Title: INTRODUCTION TO SCILAB PROGRAMMING**

**Total Credits: 02 (Credits: Theory: 00, Practical: 02)**

**Total Hours: Theory: 00, Practical: 60**

**Course Objectives:** This course focuses on the core skills necessary to work with Scilab and present an overview of Scilab features to get familiar with this environment. The Scilab language, especially its structured programming features containing real matrices and the linear algebra library are covered in this course. The definition of functions and the elementary management of input and output variables are presented. Scilab's graphical features to create 2D/3D plots and how to export that plot into a vectorial or bitmap format are also included in this course.

**Course Learning Outcomes:** This course will help students in the following ways.

- Awareness and understanding of the free software, Scilab, which provides a powerful computing environment for engineering and scientific applications.
- Scilab software includes a lot of mathematical functions and is based on a high level programming language, comprising of advanced data structures and graphical functions.
- The syntax of Scilab enables the students to visualize solutions of non-trivial problems, which are otherwise difficult to perform in a laboratory set-up. It also helps them to gain insight into complicated physics problems.
- The graphical features of Scilab are a boon to the students for visually understanding the complex nature of diverse scientific and engineering problems.
- Scicos/Xcos: an additional tool in Scilab offers a graphical analysis of the complex electrical circuits, wave phenomenon, etc.

---

- Teacher may give long duration projects based on this paper.
- Sessions on the review of experimental data analysis and its application to the specific experiments done in the lab.

**Introduction to Scilab**

Scilab installation and familiarization with Scilab environment, Command window, Figure window, Edit window, Variables and arrays, Initializing variables in Scilab, Multidimensional arrays, Sub-array, Special values, Displaying output data, data file, Scalar and array operations, Hierarchy of operations, Built in Scilab functions, Introduction to plotting, 2D and 3D plotting and graphics design, Branching Statements and program design, Relational and logical operators, the while loop, for loop, details of loop operations, break and continue statements, nested loops, logical arrays and vectorization. User defined functions, Introduction to Scilab functions, Variable passing in Scilab, optional arguments, preserving data between calls to a function, Complex and Character data, string function, Multidimensional arrays an introduction to Scilab file processing, file opening and closing, Binary I/O functions, comparing binary and formatted functions, numerical methods and developing the skills of writing a program.

**Programs:**
At least 08 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 more practice.

- **Series Expansion**

Evaluate trigonometric, logarithmic, and exponential functions by series expansion and compare the results with built-in Scilab functions.
Application to evaluation of $\pi$ (using $\tan^{-1} 1 = \frac{\pi}{4}$)

- **Matrix Algebra**

Addition/subtraction and multiplication of matrices, trace, transpose, inverse, determinant of a matrix. Eigenvalues, eigenvector, diagonalization, and function of matrix with application to physics problem.

- **Plotting of graphs**

The pre-defined functions and a variety of powerful in-built tools of Scilab should be extensively utilized for producing self-explanatory and meaningful 2D/3D graphs. This experiment should also explain how to write user-defined functions for formatting the coordinate axes of the graph and for customizing the line style, data markers, title and legends of the graphs.
The plotting can be learnt by following suggestive problems.

- Superposition of waves and formation of wave group
- Familiarization with Cartesian, cylindrical and spherical polar coordinates
- Normal and anomalous dispersion
- Blackbody radiation spectrum
- Plotting of band structure in 3D
- Plotting of vector functions: 2D/3D vector fields and its application in graphical understanding of the concept of gradient, divergence, and curl.

- **Graphics Design**

Application to computer graphics: create any arbitrary object of own choice by considering data points or functions and implement translation, reflection, shear, strain and rotation operator on the same. Plot old and new object.

- **Integration and Differentiation**

Introduction of differentiation and integration using inbuilt Scilab functions. Application to various mathematical and physical problems may be included, such as differential (gradient, divergence, and curl) and integral (line, surface, and volume) calculus. Further, this may be useful in verification of fundamental theorems for gradient, divergence, and curl.

- **Ordinary Differential Equation**

Applications of first and second order differential equations in physics problems, such as radioactive decay, motion of a freely falling object, simple harmonic motion, damped and forced oscillations etc. using Scilab built in functions.

- **Fourier Analysis**

Generating different periodic functions and their Fourier series. It should also explain how to perform integral Fourier transform of common functions like square, sine-cosine and Gaussian functions.

- **Special Functions**

Generation of special functions using user defined functions and comparison with Scilab built-in functions. This experiment is based on the implementation of special functions such as Bessel function, Legendre function, Laguerre function and Hermite function and verification of related recurrence relations. Some applications of these functions in diverse physical problems such as the study of planetary motion, diffraction of light at circular aperture and propagation of electromagnetic waves through cavity resonators can be included.

- **Scicos/Xcos**

Generating different wave function, such as square wave, sine wave, saw tooth wave etc. An application to understanding,

- Superposition of waves by concept of Lissajous figures and beat phenomenon.
- Electrical circuits, such as RC, RL, LC, series and parallel LCR etc.
- Diode circuits and its applications

**References:**

**Essential Readings:**


**1)** Urroz, G. E. (2001). Introduction to SCILAB. Retrieved from https://www.scilab.org.

**2)** Urroz, G. E. (2001). ODEs with SCILAB. Retrieved from https://www.scilab.org.

**3)** Urroz, G. E. (2001). Ordinary differential equations with SCILAB. Retrieved from https://www.math.utah.edu.

**4)** Urroz, G. E. (2001). Orthogonal Functions, Gaussian Quadrature, and Fourier analysis with SCILAB. Retrieved from https:// www.scilab.org.

**5)** Sharma, M. (2016). Scilab Codes and Programs for Physics as well as Mathematical Problems. Retrieved from https://www.bragitoff.com/

**6)** Jain, M. C. (2014). Vector Spaces and Matrices in Physics (2nd Edition). Narosa Publishing House.

**7)** Coddington, E. A. (2009). An introduction to ordinary differential equations. PHI Learning Pvt. Ltd.

**8)** Sastry, S. S. Introductory Methods of Numerical Analysis (3rd Edition). Prentice Hall of India Private Limited.
**9)** Jain, M. K.; Iyengar, S. R. K.; Jain, R. K. (2012). Numerical Methods for Scientific and Engineering Computation (6th Edition). New Age International Publisher.
**10)** Fausett, L. V. (2012). Applied Numerical Analysis-Using MATLAB. (2nd Edition). Pearson Education.
**11)** Folland, G. B. (1992). Fourier Analysis and Its Applications (Wadsworth and Brooks/ Cole Mathematics Series). Thomson Brooks/Cole.
**12)** Introduction to Electrodynamics, D.J. Griffiths, 3rd Ed., 1998, Benjamin Cummings.

**Course Code: PHYSICS SEC 8**

**Course Title: TECHNICAL DRAWING AND 3D PRINTING**

**Total Credits: 02 (Credits: Theory: 00, Practical: 02)**

**Total Hours: Theory: 00, Practical: 60**

**Syllabus to be prepared later**

**Course Code: PHYSICS SEC 9**

**Course Title: DATA ANALYSIS AND STATISTICAL METHODS**

**Total Credits: 02 (Credits: Theory: 00, Practical: 02)**

**Total Hours: Theory: 00, Practical: 60**

**Course Objectives:** The emphasis of course is to equip students with the data analysis tools for solving problems in Physics, and in general. Further, students will be exposed to computational skills required to implement the data analysis techniques.

**Course Learning Outcomes:** The data analysis methods given below will be implemented using C/C++ or Python programming language, and hence a basic knowledge of the programming language is desirable.

After completing this course, student will be able to:

- Idea of random variable and probability distribution function, which is very important for uncertainty (or error) propagations
- Fitting data points using least square fits, with uncertainties on data values
- Basic idea of interpolation, integration, and solution of ode
- Monte Carlo technique and idea of random number

---

**Introduction to Probability and Random Variables:** Review of probability, Idea of 1D random variable, probability density function – discrete (binomial) and continuous (Gaussian), Expectation value or mean value, Variance and Standard deviation.

**Least Square fitting:** Covariance and correlations in 2D random distributions, propagation of errors**,** Linear least square fit of data points both with and without uncertainties (or errors), Finding errors on the estimated parameters.

**Integration, Interpolation, and Solution of ODE:** Integration using Gauss quadrature, Lagrange Interpolation, Solution of ODE using Runge-Kutta (order 4 method)

**Random Number generation:** Idea of Monte Carlo technique, pseudo random number generation, Idea of Monte Carlo integration: estimating value of pi (or find area of circle) using Monte Carlo acceptance-rejection method.

Every student must perform experiments covering the entire syllabus.

The list of programs is only suggestive. Students should be encouraged to do more practice.

1) To plot discrete and continuous distributions and find mean, median and mode.
2) Fitting data points with and without errors using least square fitting technique, and

estimate the errors on the obtained parameters,

3) Perform error propagation on functions of two variables, while understanding the effect of covariance.
4) Performing polynomial interpolation using Lagrange Interpolating function
5) Performing Integration using Gauss quadrature method
6) Solving ODE (both first and 2nd order) using RK4 method.
7) Generating random numbers using inbuilt functions and plot the frequency distribution
8) Estimate value of pi (or find area of circle) using Monte Carlo acceptance-rejection method

**References:**


**1)** Statistics and Data Analysis: from elementary to intermediate, Ajit C. Tamhane and Dorothy D. Dunlop, Prentice Hall.

**2)** Numerical Analysis, Richard L. Burden, J. Douglas Faires and Annette M. Burden, Cengage Learning; 10th edition

**3)** Data Reduction and Error Analysis for the Physical Sciences, by Philip Bevington and D. Keith Robinson, McGraw-Hill Education; 3rd edition

**Course Code: PHYSICS SEC 10**

**Course Title: RADIATION SAFETY**

**Total Credits: 02 (Credits: Theory: 01, Practical: 01)**

**Total Hours: Theory: 15, Practical: 30**

**Course Objectives:** This course focuses 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 radiation exposure. It imparts all the skills required by a radiation safety officer or any job dealing with radiation such as X-ray operators, jobs dealing with nuclear medicine: chemotherapists, operators of PET, MRI, CT scan, gamma camera 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.
- 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 devices 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,
- Learning about the devices which apply radiations in medical sciences, such as X-ray, MRI, PET, CT-scan

---

## THEORY (Credit: 01; 15 Hours)

**Unit 1:** **Hours: 6**

**Radiation and its interaction with matter:** Basic idea of different types of radiation electromagnetic (X-ray, gamma rays, cosmic rays etc.), nuclear radiation and their origin.
Nuclear Radiation: Basic idea of Alpha, Beta, Gamma neutron radiation and their sources (sealed and unsealed sources).
Interaction of Charged Particles (including alpha particles): Heavy charged particles (e.g. accelerated ions) - Beth-Bloch Formula, Scaling laws, Mass Stopping Power, Range,

Straggling.
Interaction of Beta Particles: Collision and Radiation loss (Bremsstrahlung).
Interaction of Photons: Linear and Mass Attenuation Coefficients.
Interaction of Neutrons: Collision, slowing down and Moderation.

**Unit 2:** **Hours: 4**

**Radiation detection and monitoring devices:** Basic concepts and working principle of gas detectors, Scintillation Detectors, Solid State Detectors and Neutron Detectors, Thermo-luminescent Dosimetry.
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).

**Unit 3:** **Hours: 2**

**Radiation Units, dosage and safety management**:
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 safety management: Biological effects of ionizing radiation, Operational limits and basics of radiation hazards, its evaluation and control: radiation protection standards.

**Unit 4:** **Hours: 3**

**Application of radiation as a technique:** Application in medical science (e.g., basic principles of X-rays, MRI, PET, CT scan, Projection Imaging Gamma Camera, Radiation therapy), Archaeology, Art, Crime detection, Mining and oil. Industrial Uses: Tracing, Gauging, Material Modification, Sterilization, Food preservation.

## PRACTICAL (Credit: 01; 30 Hours)

Minimum five experiments need to be performed from the following, graphs to be plotted using any graphical plotting software

1) Estimate the energy loss of different projectiles/ions in Water and carbon, using SRIM/TRIM etc. simulation software, (different projectiles/ions to be used by different students).
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. (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. $KSO_4$ etc.). 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) Measurement of gamma ray attenuation co-efficient of aluminium using GM counter.
13) Estimation of half thickness for aluminium using GM Counter.

**References:**

**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)** Nuclear Physics: Principles and Applications by J Lilley, Wiley Publication, 2006.
**4)** Fundamental Physics of Radiology by W J Meredith and B Massey, John Wright and Sons, UK, 1989.
**5)** An Introduction to Radiation Protection by A Martin and S A Harbisor, John Willey and Sons, Inc. NewYork, 1981.


**Additional Readings:**


**1)** Radiation detection and measurement by G F Knoll, 4th Edition, Wiley Publications, 2010.
**2)** Techniques for Nuclear and Particle Physics experiments by W R Leo, Springer, 1994.
**3)** Thermoluminescence dosimetry by A F Mcknlay, Bristol, Adam Hilger (Medical Physics Hand book 5
**4)** Medical Radiation Physics by W R Hendee, Year book Medical Publishers, Inc., London, 1981.
**5)** Physics and Engineering of Radiation Detection by S N Ahmed, Academic Press Elsevier, 2007.
**6)** 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).

**References (for Laboratory Work):**


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) 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.

**Course Code: PHYSICS SEC 11**

**Course Title: INTRODUCTION TO PHYSICS OF DEVICES**

**Total Credits: 02 (Credits: Theory: 01, Practical: 01)**

**Total Hours: Theory: 15, Practical: 30**

**Course Objectives:** This paper is based on basic electrical and electronics instruments which cover the devices such as diode, photodiode, solar cell, electromagnet etc. This course also covers working of ideal and constant current source; ideal and constant voltage source; and dependent and independent current and voltage source.

**Course Learning Outcomes:** At the end of this course, students will be able to,

- Develop the basic knowledge of semiconductor device physics and electronic circuits along with the practical technological considerations and applications.
- Understand the operation of devices such as multimeter, current source and voltage source etc.

---

## THEORY (Credit: 01; 15 Hours)

**Unit 1:** **Hours: 4**

**Measurement of Voltage and current:** Working of ideal and constant current source, Ideal and constant voltage source, Dependent and independent current and voltage source. Working of moving coil galvanometer, its use as Voltmeter and Ammeter, Use of digital multimeter for measurement of R, L, C, ac and dc voltage and current, type of transistor etc.

**Unit 2:** **Hours: 6**

**Two layered devices:** Working principle and I-V characteristics of p-n junction diode, Zener diode, LED, photo-diode and solar cell. Centre-tapped and Bridge Full-wave Rectifiers, Calculation of ripple factor and rectification efficiency, basic idea about capacitor filter, Working of regulator IC 7805.

**Unit 3:** **Hours: 5**

**Electrical Appliances:** Use of capacitor/condenser in electrical motor, Uses of electrical fuses, MCBs, difference between power, neutral and ground in electrical circuits, Use of ground terminal in electrical circuits, Working of IR remote control, microwave oven and water purifier

## PRACTICAL (Credit: 01; 30 Hours)

Every student must perform at least 06 experiments for the following list.

1) To examine the performance of a constant current source and constant voltage source.
2) Making voltmeter and ammeter using galvanometer.
3) I-V characteristics of LED
4) Zener diode as voltage regulator.
5) Measurement of efficiency and fill factor of solar cell.
6) Measurement of photocurrent using photodiode with variation in intensity of incident light.
7) To design a regulated power supply (adapter) using bridge rectifier and regulator IC (7805).
8) Design an electrical switch board with fuse and power indicator.
9) The basic idea of First Aid for Electrical Emergencies.

### References (For Theory):

### Essential Readings:


**1)** Physics of Semiconductor Devices, S. M. Sze and K. K. Ng, 3rd Edition 2008, John Wiley and Sons

**2)** Electronic Devices and Circuits, A. Mottershead, 1998, PHI Learning Pvt. Ltd.

**3)** H. S. Kalsi, Electronic Instrumentation, TMH (2006).


### References (For Laboratory Work):


**1)** PC based instrumentation; Concepts and Practice, N. Mathivanan, 2007, Prentice-Hall of India

**2)** Basic Electronics: A text lab manual, P. B. Zbar, A. P. Malvino, M. A. Miller,1994, McGraw Hill

**3)** Electrical Wiring Components and Accessories and First Aid for Electrical Emergencies kvdl103.pdf (ncert.nic.in)

**Course Code: PHYSICS SEC 12**

**Course Title: INTRODUCTION TO LASER AND FIBRE OPTICS**

**Total Credits: 02 (Credits: Theory: 01, Practical: 01)**

**Total Hours: Theory: 15, Practical: 30**

**Syllabus to be prepared later**

**Course Code: PHYSICS SEC 13**

**Course Title: WEATHER FORECASTING**

**Total Credits: 02 (Credits: Theory: 01, Practical: 01)**

**Total Hours: Theory: 15, Practical: 30**

**Syllabus to be prepared later**

**Course Code: PHYSICS SEC 14**

**Course Title: EMBEDDED SYSTEM PROGRAMMING**

**Total Credits: 02 (Credits: Theory: 00, Practical: 02)**

**Total Hours: Theory: 00, Practical: 60**

**Syllabus to be prepared later**

**Course Code: PHYSICS SEC 15**

**Course Title: VERILOG AND FPGA PROGRAMMING**

**Total Credits: 02 (Credits: Theory: 00, Practical: 02)**

**Total Hours: Theory: 00, Practical: 60**

**Syllabus to be prepared later**

# GENERIC ELECTIVES COURSES (GE)

## Note: These are suggested GE courses. A student may however choose any GE from the central pool for Physics/Electronics/Mathematics

**Course Code: PHYSICS GE 1**

**Course Title: MECHANICS**

**Total Credits: 04 (Credits: Theory: 03, Practical: 01)**

**Total Hours: Theory: 45, Practical: 30**

**Course Objectives:** This course reviews the concepts of mechanics learnt at school in a more advanced perspective and goes on to build new concepts. It begins with dynamics of a system of particles and ends with the special theory of relativity. Students will appreciate the concept of rotational motion, gravitation and oscillations. The students will be able to apply the concepts learnt to several real world problems. A brief recapitulation of vector algebra and differential equations is also done to familiarize students with basic mathematical concepts which are necessary for a course on mechanics.

**Course Learning Outcomes:** Upon completion of this course, students are expected to understand the following concepts.

- Laws of motion and their application to various dynamical situations. And their applications to conservation of momentum, angular momentum and energy.
- Motion of a simple and compound pendulum
- Application of Kepler's laws to describe the motion of satellites in circular orbit.
- The concept of geosynchronous orbits
- Concept of stress and strain and relation between elastic constants
- Postulates of Special Theory of Relativity, Lorentz transformation, relativistic effects on the mass and energy of a moving body.

In the laboratory course, after acquiring knowledge of how to handle measuring instruments (like vernier calliper, screw gauge and travelling microscope) student shall embark on verifying various principles and associated measurable quantities.

## THEORY (Credit: 03; 45 Hours)

### Unit 1: Recapitulation of Vectors and Ordinary Differential Equation — Hours: 8

Vector algebra, scalar and vector product, gradient of a scalar field, divergence and curl of vectors field

Ordinary Differential Equations: First order homogeneous differential equations, second order homogeneous differential equation with constant coefficients

### Unit 2: Fundamentals of Dynamics — Hours: 10

Review of Newton's laws of motion, dynamics of a system of particles, centre of mass, determination of centre of mass for discrete and continuous systems having spherical symmetry, Conservation of momentum and energy, Conservative and non-Conservative forces, work – energy theorem for conservative forces, force as a gradient of potential energy.

### Unit 3: Rotational Dynamics and Oscillatory Motion — Hours: 14

Angular velocity, angular momentum, torque, conservation of angular momentum, Moment of inertia, Theorem of parallel and perpendicular axes, Calculation of moment of inertia of discrete and continuous objects (1-D and 2-D).

Idea of simple harmonic motion, Differential equation of simple harmonic motion and its solution, Motion of a simple pendulum and compound pendulum

### Unit 4: Gravitation — Hours: 5

Newton's Law of Gravitation, Motion of a particle in a central force field, Kepler's Laws (statements only), Satellite in circular orbit and applications, geosynchronous orbits

### Unit 5: Elasticity — Hours: 3

Concept of stress and strain, Hooke's law, elastic moduli, twisting torque on a wire, tensile strength, relation between elastic constants, Poisson's ratio, rigidity modulus

### Unit 6: Special Theory of Relativity — Hours: 5

Postulates of Special Theory of Relativity, Lorentz transformation, length contraction, time dilation, relativistic transformation of velocity, relativistic variation of mass, mass-energy equivalence

## References:

### Essential Readings:


1) Vector Analysis – Schaum's Outline, M.R. Spiegel, S. Lipschutz, D. Spellman, 2$^{nd}$ Edn., 2009, McGraw- Hill Education.
2) An Introduction to Mechanics (2/e), Daniel Kleppner and Robert Kolenkow, 2014, Cambridge University Press.
3) Mechanics Berkeley Physics Course, Vol. 1, 2/e: Charles Kittel, et. al., 2017, McGraw Hill Education
4) Mechanics, D. S. Mathur, P. S. Hemne, 2012, S. Chand.
5) Fundamentals of Physics, Resnick, Halliday and Walker 10/e, 2013, Wiley.

**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) Engineering Mechanics, Basudeb Bhattacharya, 2/e, 2015, Oxford University Press.
5) Physics for Scientists and Engineers, Randall D Knight, 3/e, 2016, Pearson Education.


## PRACTICAL (Credit: 01; 30 Hours)

The teacher is expected to give basic idea and working of various apparatus and instruments related to different experiments. Students should also be given knowledge of recording and analyzing experimental data.

Every student should perform at least 06 experiments from the following list.

1) Measurement of length (or diameter) using vernier calliper, screw gauge and travelling microscope.
2) Study the random error in observations.
3) Determination of height of a building using a sextant.
4) Study of motion of the spring and calculate (a) spring constant and, (b) acceleration due to gravity (g)
5) Determination of moment of inertia of a flywheel.
6) Determination of g and velocity for a freely falling body using digital timing technique.
7) Determination of modulus of rigidity of a wire using Maxwell's needle.
8) Determination of elastic constants of a wire by Searle's method.
9) Determination of value of g using bar pendulum.
10) Determination of value of g using Kater's pendulum.

**References:**


1) Advanced practical physics for students, B. L. Flint and H. T. Worsnop, 1971, Asia Publishing House.
2) Engineering practical physics, S. Panigrahi and 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 and Ramakrishna, 11/e, 2011, Kitab Mahal.
5) B. Sc. practical physics, Geeta Sanon, R. Chand and Co., 2016.

**Course Code: PHYSICS GE 2**

**Course Title: MATHEMATICAL PHYSICS**

**Total Credits: 04 (Credits: Theory: 03, Tutorial: 01)**

**Total Hours: Theory: 45, Tutorial: 15**

**Course Objectives:** 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,

- Understand 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.
- During the tutorial classes, students' skill will be developed to solve more problems related to the concerned topics.

---

**Unit 1:** **Hours: 6**

**Fourier series:** Periodic functions. Orthogonality of sine and cosine functions, Convergence of Fourier series and 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 (Fourier Cosine Series and Fourier Sine Series).

**Unit 2:** **Hours: 10**

**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 and Bessel Differential Equations.

**Unit 3:** **Hours: 14**

**Some Special Integrals:** Beta and Gamma Functions and Relation between them. Expression of integrals in terms of Gamma Functions.

**(4 Hours)**

**Partial Differential Equations:** Multivariable functions, Partial derivatives, Functions Solutions to partial differential equations, using separation of variables: Laplace's Equation in problems of rectangular geometry, Solution of 1D wave equation.

**(10 Hours)**

**Unit 4:** **Hours: 15**

**Complex Analysis**: Functions of complex variable, limit, continuity, Analytic function, Cauchy-Riemann equations, singular points, Cauchy Goursat Theorem, Cauchy's Integral Formula, Residues, Cauchy's Residue Theorem.

**References:**

**Essential Readings:**


1) Advanced Engineering Mathematics, Erwin Kreyszig, 2008, Wiley India.
2) Complex Variables and Applications, J.W.Brown and R.V.Churchill, 7th Ed. 2003, Tata McGraw-Hill.
3) Advanced Mathematics for Engineers and Scientists: Schaum Outline Series, M. R Spiegel, 2009, McGraw Hill Education.
4) Applied Mathematics for Engineers and Physicists, L.A. Pipes and L.R. Harvill, 2014, Dover Publications.
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, 2017, Laxmi Publications Private Limited.
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.
4) Differential Equations, George F. Simmons, 2007, McGraw Hill.
5) Mathematical methods for Scientists and Engineers, D.A.Mc Quarrie, 2003, Viva Books.

**Course Code: PHYSICS GE 3**

**Course Title: WAVES AND OPTICS**

**Total Credits: 04 (Credits: Theory: 03, Practical: 01)**

**Total Hours: Theory: 45, Practical: 30**

**Course Objectives:** This coursework reviews the concept of waves and optics learnt at school level from a more advanced perspective and builds new concepts. This course is divided into two main parts. The first part deals with vibrations and waves. The second part pertains to optics and provides the details of interference, diffraction and polarization.

**Course Learning Outcomes:** After the completion of this course, the students will have learnt the following.

- Simple harmonic motion, superposition principle and its application to find the resultant of superposition of harmonic oscillations.
- Concepts of vibrations in strings.
- Interference as superposition of waves from coherent sources.
- Basic concepts of Diffraction: Fraunhoffer and Fresnel Diffraction.
- Elementary concepts of the polarization of light.

---

**THEORY (Credit: 03; 45 Hours)**

**Unit 1:** **Hours: 10**

**Superposition of Harmonic Oscillations:** Simple harmonic motion (SHM). Linearity and Superposition Principle. Superposition of two collinear harmonic oscillations having (1) equal frequencies and (2) different frequencies (Beats). Superposition of two perpendicular harmonic oscillations: Graphical and Analytical Methods. Lissajous Figures (1:1 and 1:2) and their uses.

**Unit 2:** **Hours: 5**

**Waves Motion:** Types of waves: Longitudinal and Transverse (General idea). Travelling waves in a string, wave equation. Energy density. Standing waves in a string - modes of vibration. Phase velocity.

**Unit 3:** **Hours: 12**

**Interference of Light:** Electromagnetic nature of light. Definition and properties of wave front. Huygens Principle. Interference: Division of amplitude and division of wave front.

Young's Double Slit experiment. Fresnel's Biprism. Phase change on reflection: Stoke's treatment. Interference in Thin Films: parallel and wedge-shaped films. Newton's Rings: measurement of wavelength and refractive index.

**Unit 4:** **Hours: 12**

**Diffraction:** Fraunhofer diffraction - Single slit, Double slit and Diffraction grating. Fresnel Diffraction - Half-period zones, Zone plate, Fresnel Diffraction pattern of a straight edge using half-period zone analysis.

**Unit 5:** **Hours: 6**

**Polarization:** Transverse nature of light waves. Plane polarized light. Production and detection of linearly polarized light. Malus's Law. Idea of circular and elliptical polarization.

**References:**

**Essential Readings:**

**1)** The Physics of Waves and Oscillations: N K Bajaj, Tata Mcgraw Hill
**2)** Optics: Ajoy Ghatak, Seventh edition, Mcgraw Hill
**3)** Principle of Optics: B. K. Mathur and T. P. Pandya, Gopal Printing Press
**4)** Optics: Brij Lal and N. Subramanyam, S. Chand
**5)** The Fundamentals of Optics: A. Kumar, H. R. Gulati and D. R. Khanna, R. Chand

**Additional Readings:**

**1)** Vibrations and Waves: A. P. French, CRC
**2)** The physics of Vibrations and Waves: H. J. Pain, Wiley
**3)** Fundamentals of Optics: Jenkins and White, McGraw Hill
**4)** Optics: E. Hecht and A R. Ganesan, Pearson, India
**5)** Introduction to Optics: F. Pedrotti, L. M. Pedrotti and L. S. Pedrotti, Pearson, India

**PRACTICAL (Credit: 01; 30 Hours)**

---

Every student must perform at least 05 experiments out of the list following experiments.

**1)** To determine the frequency of an electrically maintained tuning fork by Melde's experiment and to verify $\lambda^2 - T$ Law.
**2)** To study Lissajous Figures.
**3)** Familiarization with Schuster`s focusing and determination of the angle of prism.
**4)** To determine the refractive index of the material of a prism using sodium light.
**5)** To determine the dispersive power of a prism using mercury light.
**6)** To determine wavelength of sodium light using Newton's rings.
**7)** To determine wavelength of sodium light using a plane diffraction grating.
**8)** To verify Malus's Law.
**9)** To determine the wavelength of Laser light using single slit diffraction. (Due care should be taken not to see Laser light source directly as it may cause injury to eyes.)

**References (for Laboratory Work):**


1) Advanced Practical Physics for students, B. L. Flint and H. T. Worsnop, Asia Publishing House
2) A Text Book of Practical Physics, Indu Prakash and Ramakrishna, Kitab Mahal
3) An advanced course in practical physics, D. Chattopadhyay and P. C. Rakshit, New Central Book Agency

**Course Code: PHYSICS GE 4**

**Course Title: INTRODUCTION TO ELECTRONICS**

**Total Credits: 04 (Credits: Theory: 02, Practical: 02)**

**Total Hours: Theory: 30, Practical: 60**

**Syllabus to be prepared later**

**Course Code: PHYSICS GE 5**

**Course Title: SOLID STATE PHYSICS**

**Total Credits: 04 (Credits: Theory: 03, Tutorial: 01)**

**Total Hours: Theory: 45, Tutorial: 15**

**Syllabus to be prepared later**

**Course Code: PHYSICS GE 6**

**Course Title: INTRODUCTORY ASTRONOMY**

**Total Credits: 04 (Credits: Theory: 03, Tutorial: 01)**

**Total Hours: Theory: 45, Tutorial: 15**

**Course Objectives:** 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 be introduced to the Indian contribution to astronomy starting from ancient times up to the modern era. They will learn about diverse set of astronomical 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. Students will also be introduced to internet astronomy and the citizen science research platform in astronomy. The course presupposes school level understanding of mathematics and physics.

**Course Learning Outcomes:** After completing this course, student will gain an understanding of,

- Different types of telescopes, diurnal and yearly motion of astronomical objects, 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
- Current research in detection of exoplanets
- Basic structure of different galaxies and rotation of the Milky Way galaxy
- Distribution of chemical compounds in the interstellar medium and astrophysical conditions necessary for the emergence and existence of life
- Internet based astronomy and the collaborative citizen astronomy projects
- India's contribution to astronomy, both in ancient times and in modern era.

---

**Unit 1:** **Hours: 8**

**Introduction to Astronomy and Astronomical Scales:** History of astronomy, wonders of the Universe, overview of the night sky, diurnal and yearly motions of the Sun, size, mass, density and temperature of astronomical objects, basic concepts of positional astronomy: Celestial sphere, Astronomical coordinate systems, Horizon system and Equatorial system

**Unit 2:** **Hours: 6**

**Basic Parameters of Stars:** Stellar energy sources, determination of distance by parallax method, aberration, proper motion, brightness, radiant flux and luminosity, apparent and absolute magnitude scales, distance modulus, determination of stellar temperature and radius, basic results of Saha ionization formula and its applications for stellar astrophysics, stellar spectra, dependence of spectral types on temperature, luminosity classification, stellar evolutionary track on Hertzsprung-Russell diagram

**Unit 3:** **Hours: 7**

**Astronomical Instruments:** Observing through the atmosphere (Scintillation, Seeing, Atmospheric Windows and Extinction). Basic optical definitions for telescopes: Magnification, Light Gathering Power, Limiting magnitude, Resolving Power, Diffraction Limit. Optical telescopes, radio telescopes, Hubble space telescope, James Web space telescope, Fermi Gamma ray space telescope.

**Astronomy in the Internet Age:** Overview of Aladin Sky Atlas, Astrometrica, Sloan Digital Sky Survey, Stellarium, virtual telescope

**Citizen Science Initiatives:** Galaxy Zoo, SETI@Home, RAD@Home India

**Unit 4:** **Hours: 8**

**Sun and the solar system:** Solar parameters, Sun's internal structure, solar photosphere, solar atmosphere, chromosphere, corona, solar activity, origin of the solar system, the nebular model, tidal forces and planetary rings

**Exoplanets:** Detection methods

**Unit 5:** **Hours: 12**

**Physics of Galaxies:** Basic structure and properties of different types of Galaxies, Nature of rotation of the Milky Way (Differential rotation of the Galaxy), Idea of dark matter

**Cosmology and Astrobiology:** Standard Candles (Cepheids and SNe Type1a), Cosmic distance ladder, Olber's paradox, Hubble's expansion, History of the Universe, Chemistry of life, Origin of life, Chances of life in the solar system

**Unit 6:** **Hours: 4**

**Astronomy in India:** Astronomy in ancient, medieval and early telescopic era of India, current Indian observatories (Hanle-Indian Astronomical Observatory, Devasthal Observatory, Vainu Bappu Observatory, Mount Abu Infrared Observatory, Gauribidanur Radio Observatory, Giant Metre-wave Radio Telescope, Udaipur Solar Observatory, LIGO-India) (qualitative discussion), Indian astronomy missions (Astrosat, Aditya)

**References:**

**Essential Readings:**

**1)** Seven Wonders of the Cosmos, Jayant V Narlikar, Cambridge University Press
**2)** Fundamental of Astronomy, H. Karttunen et al. Springer
**3)** Modern Astrophysics, B.W. Carroll and D.A. Ostlie, Addison-Wesley Publishing Co.
**4)** Introductory Astronomy and Astrophysics, M. Zeilik and S.A. Gregory, Saunders College Publishing.

5) The Molecular Universe, A.G.G.M. Tielens, Reviews of Modern Physics, Volume 85, July-September, 2013
6) Astronomy in India: A Historical Perspective, Thanu Padmanabhan, Springer

### Useful websites for astronomy education and citizen science research platform

1) https://aladin.u-strasbg.fr/
2) http://www.astrometrica.at/
3) https://www.sdss.org/
4) http://stellarium.org/
5) https://www.zooniverse.org/projects/zookeeper/galaxy-zoo/
6) https://setiathome.berkeley.edu/
7) https://www.radathomeindia.org/

### Additional Readings:

1) Explorations: Introduction to Astronomy, Thomos Arny and Stephen Schneider, McGraw Hill
2) Astrophysics Stars and Galaxies K D Abhyankar, Universities Press
3) Textbook of Astronomy and Astrophysics with elements of cosmology, V.B. Bhatia, Narosa Publication.
4) Baidyanath Basu, An introduction to Astrophysics, Prentice Hall of India Private Limited.
5) The Physical Universe: An Introduction to Astronomy, F H Shu, University Science Books

**Course Code: PHYSICS GE 7**

**Course Title: BIOLOGICAL PHYSICS**

**Total Credits: 04 (Credits: Theory: 03, Tutorial: 01)**

**Total Hours: Theory: 45, Tutorial: 15**

**Syllabus to be prepared later**

**Course Code:** PHYSICS GE 8

**Course Title:** NUMERICAL ANALYSIS AND COMPUTATIONAL PHYSICS

**Total Credits:** 04 (Credits: Theory: 02, Practical: 02)

**Total Hours:** Theory: 30, Practical: 60

## Syllabus to be prepared later

**Course Code: PHYSICS GE 9**

**Course Title: APPLIED DYNAMICS**

**Total Credits: 04 (Credits: Theory: 03, Tutorial: 01)**

**Total Hours: Theory: 45, Tutorial: 15**

**Syllabus to be prepared later**

**Course Code: PHYSICS GE 10**

**Course Title: QUANTUM INFORMATION**

**Total Credits: 04 (Credits: Theory: 03, Tutorial: 01)**

**Total Hours: Theory: 45, Tutorial: 15**

**Syllabus to be prepared later**

**Course Code: PHYSICS GE 11**

**Course Title: ELECTRICITY AND MAGNETISM**

**Total Credits: 04 (Credits: Theory: 03, Practical: 01)**

**Total Hours: Theory: 45, Practical: 30**

**Course Objectives:** This course begins with theorems of network analysis which are required to perform the associated experiments in the laboratory. Then course delves into the elementary vector analysis, an essential mathematical tool for understanding static electric field and magnetic field. By the end of the course student should appreciate Maxwell's equations.

**Course Learning Outcomes (Theory):** At the end of this course the student will be able to,

- Apply Coulomb's law to line, surface, and volume distributions of charges.
- Apply Gauss's law of electrostatics to distribution of charges
- Understand the effects of electric polarization and concepts of bound charges in dielectric materials
- Understand and calculate the vector potential and magnetic field of arbitrary current distribution
- Understand the concept of bound currents and ferromagnetism in magnetic materials

---

**THEORY (Credit: 03; 45 Hours)**

**Unit 1:** **Hours: 15**

**Network Analysis:** Superposition, Thevenin, Norton theorems and their applications in DC and AC circuits with more than one sources. Maximum Power Transfer theorem for AC circuits

**(6 Hours)**

**Mathematical Preliminaries:**

Concept of scalar and vector fields, Gradient of a scalar field, Divergence and curl of vector fields and their physical interpretation, Conservative forces and Laplace and Poisson equations.

**(4 Hours)**

Concept of a line integral of a scalar and vector field, surface integral of vector fields and volume integral. Gauss's theorem, Stoke's theorem.

**(5 Hours)**

**Unit 2:** **Hours: 15**

**Electric Field and Electric Potential for continuous charge distributions:** Electric field due to a line charge, surface charge and volume charge distributions, Electric field vector as negative gradient of scalar potential, Ambiguities of Electric potential, Differential and integral forms of Gauss's Law, Applications of Gauss's Law to various charge distributions with spherical, cylindrical and planar symmetries. Uniqueness theorem.

**(7 Hours)**

**Electric Field in Matter:** Bound charges due to polarization and their physical interpretation. Average electric field inside a dielectric, Electric Field in spherical and cylindrical cavities of a dielectric, Displacement vector and its boundary conditions, Gauss' Law in the presence of dielectrics, Linear dielectrics: electric susceptibility and dielectric constant, Boundary value problems with linear dielectrics.

**(8 Hours)**

**Unit 3:** **Hours: 15**

**Magnetic Field:** Divergence and curl of magnetic field B, Magnetic field due to arbitrary current distribution using Biot-Savart law, Ampere's law, integral and differential forms of Ampere's Law, Vector potential and its ambiguities.

**(4 Hours)**

**Magnetic Properties of Matter:** Magnetization vector. Bound Currents, Magnetic Intensity. Differential and integral form of Ampere's Law in the presence of magnetised materials. Magnetic susceptibility and permeability. Ferromagnetism (Hund's rule).

**(6 hours)**

**Electrodynamics:** Faraday's Law, Lenz's Law, inductance. Electromotive force, Ohm's Law ($\vec{J} = \sigma\vec{E}$). Energy stored in a Magnetic Field. Charge Conservation, Continuity equation, Differential and integral forms of Maxwell's equations in matter.

**(5 hours)**

**References:**

**Essential Readings:**


1) Introduction to Electrodynamics, D. J. Griffiths, 4th Edn., 2015, Pearson Education India Learning Private Limited.
2) Schaum's Outlines of Electromagnetics, M. Nahvi and J. A. Edminister, 2019, McGraw-Hill Education.
3) Electromagnetic Fields and Waves, Paul Lorrain and Dale Corson, 1991, W. H. Freeman.
4) Electricity and Magnetism, Edward M. Purcell, 1986, McGraw-Hill Education
5) Network, Lines and Fields, John D. Ryder, 2nd Edn., 2015, Pearson.
6) Introductory circuit analysis, R. Boylestead, 2016, Pearson.
7) Electricity and Magnetism, Tom Weideman, University of California Davis. [url: https://zhu.physics.ucdavis.edu/Physics9C-C_2021/Physics%209C_EM%20by%20Tom%20Weideman.pdf]

**Additional Readings:**


1) Feynman Lectures Vol. 2, R. P. Feynman, R. B. Leighton, M. Sands, 2008, Pearson Education
2) Electricity, Magnetism and Electromagnetic Theory, S. Mahajan and Choudhury, 2012, Tata McGraw
3) Fundamentals of Physics, Resnick, Halliday and Walker 10/e, 2013, Wiley


**PRACTICAL (Credit: 01; 30 Hours)**

**Course Learning Outcome:**

- To understand working of Arduino Microcontroller System
- To use Arduino to measure time, count events and time between events
- To use Arduino to measure voltage/current/resistance
- To use Arduino to measure various physical parameters like magnetic field

**Unit I (Mandatory)**

**Arduino Programming**

Introduction to Arduino Microcontroller platform. Getting acquainted with the Arduino IDE and Basic Sketch structure. Digital Input and output. Measuring time and events. Measuring analog voltage. Generating analog voltage using Pulse Width Modulation. Serial communication and serial monitor. Programming using Interrupts.

**Unit II Exploring electrical properties of matter using Arduino (at least one experiment)**

1) To study the characteristics of a series RC Circuit.
2) To study response curve of a Series LCR circuit and determine its (a) Resonant frequency, Impedance at resonance, (c) Quality factor Q, and (d) Band width.
3) Diode Charateristics:
   (a) To study characteristics of diode and estimate Boltzman constant.
   (b) To study characteristics of LED and estimate Planck's constant

**Unit III Exploring magnetic properties of matter using Arduino**

To verify Faraday's law and Lenz's law by measuring induced voltage across a coil subjected to varying magnetic field. Also, estimate dipole moment of the magnet.

**Unit IV DC and AC Bridges (at least one experiment)**

1) To compare capacitances using De Sauty's bridge
2) To determine a low resistance by Carey Foster bridge

**Unit V Network Theorems (at least one experiment)**

1) To verify the Thevenin and Norton theorems
2) To verify the Superposition, and Maximum Power Transfer Theorems

**References (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 and B. Mallick, 2015, Cengage Learning India Pvt. Ltd.
3) A Text Book of Practical Physics, I. Prakash and Ramakrishna, 11th Ed.2011, Kitab Mahal
4) Practical Physics, G.L. Squires, 2015, 4th Edition, Cambridge University Press

**Course Code: PHYSICS GE 12**

**Course Title: THERMAL PHYSICS**

**Total Credits: 04 (Credits: Theory: 03, Practical: 01)**

**Total Hours: Theory: 45, Practical: 30**

**Course Objectives:** This course will review the basic concepts of Thermodynamics, Kinetic Theory of gases with a brief introduction to Statistical Mechanics. The primary goal is to understand the applications of fundamental laws of thermodynamics to various 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 molecule through statistical mechanics.

**Course Learning Outcomes:** At the end of this course, students will,

- Get an essence of 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, mean free path of molecular collisions, viscosity, thermal conductivity and diffusion.
- Learn about the black body radiations, Stefan- Boltzmann's law, Rayleigh-Jean's law and Planck's law and their significances.
- Learn the basics of 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 coefficient of resistance, study variation of thermo-emf across two junctions of a thermocouple with temperature etc.

---

## THEORY (Credit: 03; 45 Hours)

**Unit 1:** **Hours: 12**

**Laws of Thermodynamics**: Fundamental basics of Thermodynamic system and variables, Zeroth Law of Thermodynamics and temperature, First law and internal energy, various thermodynamical processes, Applications of First Law: general relation between $C_P$ and $C_V$, work done during various processes, Compressibility and Expansion Coefficient, reversible and irreversible processes, Second law: Kelvin-Planck and Clausius statements , Carnot engine, Carnot cycle and theorem, basic concept of Entropy, Entropy changes in reversible and irreversible processes, Clausius inequality, Entropy-temperature diagrams.

**Unit 2:** **Hours: 8**

**Thermodynamical Potentials**: Enthalpy, Gibbs, Helmholtz and Internal Energy functions, Maxwell's relations and applications - Clausius Clapeyron Equation, Expression for ($C_P$ – $C_V$), $C_P/C_V$, TdS equations, energy equations for ideal gases.

**Unit 3:** **Hours: 8**

**Kinetic Theory of Gases**: Derivation of Maxwell's law of distribution of velocities and its experimental verification, Mean free path (zeroth order only), Transport Phenomena: Viscosity, Conduction and Diffusion (for vertical case).

**Unit 4:** **Hours: 7**

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

**Unit 5:** **Hours: 10**

**Statistical Mechanics**: Macrostate and Microstate, phase space, Entropy and Thermodynamic Probability, Maxwell-Boltzmann law, Fermi-Dirac distribution law - Bose-Einstein distribution law - comparison of three statistics.

**PRACTICAL (Credit: 01; 30 Hours)**

- 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.

The students are required to do at least four experiments from the following list.

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 by steam or electrical heating.
6) To determine 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) A Treatise on Heat, Meghnad Saha, and B. N. Srivastava, 1969, Indian Press.
2) Heat and Thermodynamics, M. W. Zemasky and R. Dittman, 1981, McGraw Hill.
3) Thermodynamics, Kinetic theory and statistical thermodynamics, F. W. Sears and G. L. Salinger. 1988, Narosa.
4) Thermal Physics, A. Kumar and S.P. Taneja, 2014, R. Chand Publications.
5) Thermal Physics: S. C. Garg, R. M. Bansal and C. K. Ghosh, $2^{nd}$ Ed. Tata McGraw-Hill.

**Additional Readings:**

1) An Introduction to Thermal Physics: D. Schroeder 2021, Oxford Univ. Press (earlier published by Pearsons).
2) Concepts in Thermal Physics: Blundell and Blundell, $2^{nd}$ Ed. 2009, Oxford Univ. Press.
3) Heat, Thermodynamics and Statistical Physics, Brij Lal, N. Subrahmanyam and P. S. Hemne, S. Chand and Company.

**References (For Laboratory Work):**

1) Advanced Practical Physics for students, B. L. Flint and H. T. Worsnop, 1971, Asia Publishing House.
2) A Text Book of Practical Physics, Indu Prakash and Ramakrishna, $11^{th}$ Edition, 2011, Kitab Mahal.
3) A Laboratory Manual of Physics for Undergraduate Classes, D.P. Khandelwal, 1985, Vani Publication.
4) Practical Physics, G.L. Squires, 2015, $4^{th}$ Edition, Cambridge University Press.
5) An Advanced Course in Practical Physics, D. Chattopadhyay and P.C. Rakshit, New Central Book Agency

**Course Code: PHYSICS GE 13**

**Course Title: MODERN PHYSICS**

**Total Credits: 04 (Credits: Theory: 03, Practical: 01)**

**Total Hours: Theory: 45, Practical: 30**

**Course Objectives:** The objective of this course is to teach the physics foundation 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:** After getting exposure to this course, the following topics would have learnt,

- Main aspects of the inadequacies of classical mechanics as well as understanding of the historical development of quantum mechanics, laying the foundation of modern physics.
- Formulation of Schrodinger equation and the idea of probability interpretation associated with wave-functions.
- The spontaneous and stimulated emission of radiation, optical pumping and population inversion. Basic lasing action.
- The properties of nuclei like density, size, binding energy, nuclear force and structure of atomic nucleus, liquid drop model and mass formula.
- Radioactive decays like alpha, beta, gamma decay. Neutrino, its properties and its role in theory of beta decay.
- Fission and fusion: Nuclear processes to produce nuclear energy in nuclear reactor and stellar energy in stars.

In the laboratory course, the students will get opportunity to measure Planck's constant, verify photoelectric effect, determine e/m of electron and work function of a metal. They will also find wavelength of LASER sources by single and double slit experiment, wavelength and angular spread of He-Ne LASER using plane diffraction grating.

## THEORY (Credit: 03; 45 Hours)

**Unit 1:** **Hours: 10**

**Origin of Modern Physics** Blackbody Radiation: Failure of explanation from classical theory; Planck's idea of a quantum; Quantum theory of Light: Photo-electric effect and Compton scattering. de Broglie wavelength and matter waves; Davisson-Germer experiment;

Wave description of particles by wave packets. Group and Phase velocities and relation between them.

**Unit 2** **Hours: 10**

**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.

**Uncertainty principle:** Gamma ray microscope thought experiment; Wave-particle duality leading to Heisenberg uncertainty principle; Impossibility of an electron being in the nucleus. Energy-time uncertainty principle; origin of natural width of emission lines.

**Unit 3** **Hours: 10**

**Basics of quantum Mechanics**: Two-slit interference experiment with photons and electrons; Concept of wave functions, linearity and superposition. Time independent Schrodinger wave equation for non-relativistic particles; Momentum and Energy operators; physical interpretation of a wave function, probabilities, normalization and probability current densities in one dimension. Problem: One dimensional infinitely rigid box. An application: Quantum dot.

**Unit 4** **Hours: 5**

**X-rays**: Ionizing Power, X-ray Diffraction, Bragg's Law. Critical Potentials, X-rays-Spectra: Continuous and Characteristic X-rays, Moseley's Law.

**LASERs:** Properties and applications of Lasers. Emission (spontaneous and stimulated emissions) and absorption processes, Metastable states, components of a laser and lasing action.

**Unit 5** **Hours: 10**

**Nuclear Physics**: Size and structure of atomic nucleus and its relation with atomic weight; Nature of nuclear force, Stability of the nucleus; N-Z graph, Drip line nuclei, Binding Energy, Liquid Drop model: semi-empirical mass formula.

**Radioactivity: D**ifferent equilibrium, Alpha decay; Beta decay: energy released, spectrum and Pauli's prediction of neutrino; Gamma ray emission, energy-momentum conservation:

**Fission and fusion:** Mass deficit and generation of energy; Fission: nature of fragments and emission of neutrons. Fusion and thermonuclear reactions driving stellar evolution (brief qualitative discussions only).

**References:**

**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)** Concepts of Nuclear Physics by B. L. Cohen, Tata McGraw Hill Publication, 1974.
**5)** Quantum Mechanics: Theory and Applications, (2019), Ajoy Ghatak and S. Lokanathan, Laxmi Publications, New Delhi

### 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, Robert Eisberg and Robert Resnick, 2nd Edn., 2002, Wiley.
**7)** Basic ideas and concepts in Nuclear Physics: An introductory approach by K Heyde, third edition, IOP Publication, 1999.

### PRACTICAL (Credit: 01; 30 Hours)

- 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.

Student should perform at least 06 experiments from the following list of experiments.

1) Measurement of Planck's constant using black body radiation and photo-detector.
2) Photo-electric effect: estimate Planck's constant using graph of maximum energy of photo-electrons versus frequency of light.
3) To determine work function of material of filament of directly heated vacuum diode.
4) To determine the Planck's constant using LEDs, using at least 4 LEDs.
5) To determine the wavelength of H-alpha emission line of Hydrogen atom.
6) To determine the value of e/m by (a) Magnetic focusing or (b) Bar magnet.
7) To setup the Millikan oil drop apparatus and determine the charge of an electron.
8) To show the tunneling effect in tunnel diode using I-V characteristics.
9) To determine the wavelength of laser source using diffraction of single slit.
10) To determine wavelength and angular spread of He-Ne laser using plane diffraction grating.
11) To determine the wavelength of laser source using diffraction of double slits.

**References (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) Practical Physics, G.L. Squires, 2015, 4th Edition, Cambridge University Press.
5) B. Sc. Practical Physics, Geeta Sanon, R. Chand, 2016.

**Course Code: PHYSICS GE 14**

**Course Title: INTRODUCTORY ASTRONOMY**

**Total Credits: 04 (Credits: Theory: 03, Tutorial: 01)**

**Total Hours: Theory: 45, Tutorial: 15**

**Course Objectives:** 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 be introduced to the Indian contribution to astronomy starting from ancient times up to the modern era. They will learn about diverse set of astronomical 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. Students will also be introduced to internet astronomy and the citizen science research platform in astronomy. The course presupposes school level understanding of mathematics and physics.

**Course Learning Outcomes:** After completing this course, student will gain an understanding of,

- Different types of telescopes, diurnal and yearly motion of astronomical objects, 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
- Current research in detection of exoplanets
- Basic structure of different galaxies and rotation of the Milky Way galaxy
- Distribution of chemical compounds in the interstellar medium and astrophysical conditions necessary for the emergence and existence of life
- Internet based astronomy and the collaborative citizen astronomy projects
- India's contribution to astronomy, both in ancient times and in modern era.

---

**Unit 1:** **Hours: 8**

**Introduction to Astronomy and Astronomical Scales:** History of astronomy, wonders of the Universe, overview of the night sky, diurnal and yearly motions of the Sun, size, mass, density and temperature of astronomical objects, basic concepts of positional astronomy: Celestial sphere, Astronomical coordinate systems, Horizon system and Equatorial system

**Unit 2:** **Hours: 6**

**Basic Parameters of Stars:** Stellar energy sources, determination of distance by parallax method, aberration, proper motion, brightness, radiant flux and luminosity, apparent and absolute magnitude scales, distance modulus, determination of stellar temperature and radius, basic results of Saha ionization formula and its applications for stellar astrophysics, stellar spectra, dependence of spectral types on temperature, luminosity classification, stellar evolutionary track on Hertzsprung-Russell diagram

**Unit 3:** **Hours: 7**

**Astronomical Instruments:** Observing through the atmosphere (Scintillation, Seeing, Atmospheric Windows and Extinction). Basic optical definitions for telescopes: Magnification, Light Gathering Power, Limiting magnitude, Resolving Power, Diffraction Limit. Optical telescopes, radio telescopes, Hubble space telescope, James Web space telescope, Fermi Gamma ray space telescope.

**Astronomy in the Internet Age:** Overview of Aladin Sky Atlas, Astrometrica, Sloan Digital Sky Survey, Stellarium, virtual telescope

**Citizen Science Initiatives:** Galaxy Zoo, SETI@Home, RAD@Home India

**Unit 4:** **Hours: 8**

**Sun and the solar system:** Solar parameters, Sun's internal structure, solar photosphere, solar atmosphere, chromosphere, corona, solar activity, origin of the solar system, the nebular model, tidal forces and planetary rings

**Exoplanets:** Detection methods

**Unit 5:** **Hours: 12**

**Physics of Galaxies:** Basic structure and properties of different types of Galaxies, Nature of rotation of the Milky Way (Differential rotation of the Galaxy), Idea of dark matter

**Cosmology and Astrobiology:** Standard Candles (Cepheids and SNe Type1a), Cosmic distance ladder, Olber's paradox, Hubble's expansion, History of the Universe, Chemistry of life, Origin of life, Chances of life in the solar system

**Unit 6:** **Hours: 4**

**Astronomy in India:** Astronomy in ancient, medieval and early telescopic era of India, current Indian observatories (Hanle-Indian Astronomical Observatory, Devasthal Observatory, Vainu Bappu Observatory, Mount Abu Infrared Observatory, Gauribidanur Radio Observatory, Giant Metre-wave Radio Telescope, Udaipur Solar Observatory, LIGO-India) (qualitative discussion), Indian astronomy missions (Astrosat, Aditya)

**References:**

**Essential Readings:**

1) Seven Wonders of the Cosmos, Jayant V Narlikar, Cambridge University Press
2) Fundamental of Astronomy, H. Karttunen et al. Springer
3) Modern Astrophysics, B.W. Carroll and D.A. Ostlie, Addison-Wesley Publishing Co.

4) Introductory Astronomy and Astrophysics, M. Zeilik and S.A. Gregory, Saunders College Publishing.
5) The Molecular Universe, A.G.G.M. Tielens (Sections I, II and III), Reviews of Modern Physics, Volume 85, July-September, 2013
6) Astronomy in India: A Historical Perspective, Thanu Padmanabhan, Springer


### Useful websites for astronomy education and citizen science research platform

1) https://aladin.u-strasbg.fr/
2) http://www.astrometrica.at/
3) https://www.sdss.org/
4) http://stellarium.org/
5) https://www.zooniverse.org/projects/zookeeper/galaxy-zoo/
6) https://setiathome.berkeley.edu/
7) https://www.radathomeindia.org/

### Additional Readings:


1) Explorations: Introduction to Astronomy, Thomos Arny and Stephen Schneider, McGraw Hill
2) Astrophysics Stars and Galaxies K D Abhyankar, Universities Press
3) Textbook of Astronomy and Astrophysics with elements of cosmology, V.B. Bhatia, Narosa Publication.
4) Baidyanath Basu, An introduction to Astrophysics, Prentice Hall of India Private Limited.
5) The Physical Universe: An Introduction to Astronomy, F H Shu, University Science Books

**Course Code: PHYSICS GE 15**

**Course Title: QUANTUM MECHANICS**

**Total Credits: 04 (Credits: Theory: 03, Tutorial: 01)**

**Total Hours: Theory: 45, Tutorial: 15**

**Syllabus to be prepared later**

**Course Code: PHYSICS GE 16**

**Course Title: INTRODUCTION TO EMBEDDED SYSTEM DESIGN**

**Total Credits: 04 (Credits: Theory: 02, Practical: 02)**

**Total Hours: Theory: 30, Practical: 60**

**Syllabus to be prepared later**

**Course Code: PHYSICS GE 17**

**Course Title: NANO PHYSICS**

**Total Credits: 04 (Credits: Theory: 02, Practical: 02)**

**Total Hours: Theory: 30, Practical: 60**

**Syllabus to be prepared later**

**Course Code: PHYSICS GE 18**

**Course Title: PHYSICS OF DETECTORS**

**Total Credits: 04 (Credits: Theory: 03, Tutorial: 01)**

**Total Hours: Theory: 45, Tutorial: 15**

**Syllabus to be prepared later**

**Course Code: PHYSICS GE 19**

**Course Title: NUCLEAR AND PARTICLE PHYSICS**

**Total Credits: 04 (Credits: Theory: 03, Tutorial: 01)**

**Total Hours: Theory: 45, Tutorial: 15**

**Syllabus to be prepared later**

**Course Code: PHYSICS GE 20**

**Course Title: ATOMIC AND MOLECULAR PHYSICS**

**Total Credits: 04 (Credits: Theory: 03, Tutorial: 01)**

**Total Hours: Theory: 45, Tutorial: 15**

**Syllabus to be prepared later**