पूर्वोत्तर क्षेत्रीय विज्ञान एवं प्रौद्योगिकी संस्थान

North Eastern Regional Institute of Science & Technology

(मानद् विश्वविद्यालय, शिक्षा मंत्रालय, भारत सरकार)

(Deemed to be university, MoE, Govt of India)

निर्जुली, ईटानगर अरुणाचल प्रदेश – 791 109

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भौतिकी विभाग

DEPARTMENT OF PHYSICS

Four Year B.Sc. (Physics)

To be implemented from Academic Year 2025-2026

Syllabus of B.Sc.(Physics) as per NEP- 2020

Abbreviations Used:

- CO : Course Outcomes
- PS : Programme Structure
- TLP : Teaching-Learning Process
- UG : Undergraduate
- CC : Core Course
- MC : Minor Course
- MDC : Multidisciplinary Course
- OE : Generic Electives
- OP : Open Electives
- VSC : Vocational Skill Courses
- SEC : Skill Enhancement Courses
- CVAC : Common Value-Added Course
- AEC : Ability Enhancement Courses

1. *Introduction to Undergraduate Degree Course in Physics:*

The undergraduate (UG) degree program in Physics is a VI-semester course spread over three academic years *or* an VIII-semester course spread over four academic years, as per UGC-F-2022 recommendations. The focus of the Teaching Learning Process (TLP) is the students. It has included both theoretical and practical aspects. It assures that students receive in-depth knowledge and a strong foundation in the subject while permitting flexibility in the program's structure. In addition to the Core Course, students can choose minor courses, vocational courses, and exit courses from the curriculum. The interdisciplinary and multidisciplinary approach as well as adherence to innovative techniques within the curriculum framework will thus be emphasized. Additionally, it provides students with the greatest amount of flexibility in their undergraduate (UG) studies, even granting them the freedom to eventually design a degree with several exit options. Without sacrificing instruction or learning outcomes, both qualitatively and quantitatively, students have various exit options based on their requirements and desires regarding their life goals. This will meet students' current needs in terms of guaranteeing their pathways to further education or employment.

2. *Programme Duration and Exit Options:*

The minimum credit to be earned by a student per semester is 15 credits. However, students are advised to earn maximum credits of that 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. Students exiting the program after securing **40 credits** will be awarded ***UG Certificate*** in the relevant **Discipline/Subjec**t provided, they will earn **4 additional credits** in (exit course) work-based vocational courses offered during the summer vacation or internship/apprenticeship in addition to **6 credits** from skill-based courses during the first and second semesters. Students exiting the program after securing **80 credits** will be awarded a **UG Diploma** in the relevant **Discipline/Subjec**t provided they secure additional **4 credits** in skill based vocational courses offered during the first year or second-year summer vacation. Students exiting the program after securing **120 credits** will be awarded **UG Degree** in the relevant Discipline/**Subjec**t. Students for a 4-year **UG Degree (Honors)** need to complete additional **(3, 3, 2) Credits** major/minor courses in place of **MOOC** courses or need to complete additional **(4, 4, 4) Credits** major courses in place of Project.

A. **Major Discipline (Physics):** A student who completes the eighth semester of a four-year undergraduate program in Physics (core courses) will receive a B.Sc. Honors degree with a major in Physics, if they earn at least 50% of the total credits or at least 80 credits out of 160 credits.

B. Minor Discipline: A student of B.Sc. (Hons.) Physics may be awarded Minor in a discipline, other than Physics, on completion of VIII Semester, if he/she earns minimum 28 credits from six minor courses of that discipline.

3. ***Objectives of the Program***

The undergraduate (UG) degree course in Physics aims to provide:

- The ability and knowledge to pursue higher education and research in physics and related multidisciplinary fields, which will facilitate students' career and entrepreneurial endeavors.
- Teamwork, scientific reasoning, critical and analytical thinking, problem-solving, and communication skills.
- The ability to solve problems involving both theoretical and applied physics with competence and proficiency.
- A thorough understanding of physics by comprehension of fundamental ideas, theories, and applications.
- Knowledge of the most recent developments in physics and related fields and research.
- A favorable learning atmosphere to guarantee students' cognitive growth.
- Adequate knowledge of the subject topic, which helps students prepare for competitive exams like the Civil Services Examinations, GATE, GRE, IIT-JAM, UGC-CSIR NET/JRF, and others.
- Moral and ethical consciousness, competence, innovation, and a commitment to lifelong learning.
- Proficiency in multiple languages and cultures.

4. ***Program Outcomes:***

The physics program aims to produce graduates who have a solid understanding of physical concepts, scientific inquiry, critical thinking, and problem-solving abilities in addition to excellent laboratory, research, and communication skills.

The following are the learning objectives for the physics course for undergraduates:

- ***Role of Physics:***

  Students will gain an understanding and admiration of the important role that physics plays in contemporary global and societal concerns. The skills and knowledge they will gain from the program will enable them to address and contribute to such situations. To manage a project through to completion and adhere to safety and laboratory hygiene rules and practices, as well as responsible and ethical scientific conduct, they will be able to identify and mobilize the necessary resources.

- ***Physical Concepts:***

  Recognize and use basic physical concepts to evaluate and resolve issues in a variety of settings.

- ***Development of Research Skills:***

  This course gives students the chance to develop their research and innovation skills through internships, projects, community engagement, dissertations, entrepreneurship, and academic projects. Students will be able to exhibit advanced abilities in data analysis, research ethics, information management, and literature surveys.

• ***Scientific Inquiry:***

To test theories, and hypotheses and find answers to scientific questions, design, carry out, and present experiments and studies.

• ***Hands-on/ Laboratory Skills:***

Analytical, computational, and instrumentation abilities will be imparted through extensive practical/laboratory activities and demonstration of expertise. When it comes to gathering, assessing, analyzing, and presenting data- both quantitative and qualitative students will be able to exhibit mature skills.

• ***Problem-Solving:***

Employ mathematical methods and physical concepts to tackle complex physics and related problems.

• ***In-depth disciplinary knowledge:***

The student will gain thorough knowledge and comprehension of the basic ideas, theoretical principles, and procedures in the primary and related fields of physics. The core papers will offer a comprehensive grasp of the subject. Elective courses offered to the student will provide specialized understanding rooted in the core and interdisciplinary areas.

• ***Interdisciplinary Approach:***

Utilize physical concepts to comprehend and address issues in various fields, including biology, engineering, and environmental science.

• ***Critical and Lateral Thinking:***

The program of study will foster creativity, ingenuity, and the capacity to apply the fundamental ideas and concepts of physics and related subjects outside of the classroom to practical situations. Students will be able to differentiate between essential and insignificant facts and information, identify between objective and biased information, use logic to reach firm conclusions, determine whether conclusions are supported by enough evidence, derive accurate quantitative results, make logical assessments, and reach qualitative judgments by predetermined guidelines. Analyze arguments, evidence, and physical phenomena critically to draw well-informed judgments.

• ***Ethical Practice:***

Exhibit knowledge of the ethical issues of data management, scientific research, and professional conduct.

5. ***Program Structure:***

The detailed Credit framework of the undergraduate degree program in Physics is provided below:

Semester I (First Year)

Sl. No.	Course Code	Course Title	L	T	P	Course Credit	Course Category
1	PHCC101	Electricity and Magnetism	3	0	0	3	CC
2	PHCC103	Mechanics	3	0	0	3	CC
3	PHMC101	Fundamentals of Physics I	3	0	0	3	MC
4	PHSE102	General Physics Lab I	0	0	6	3	SEC
5	MAMD101	Calculus	3	0	0	3	MDC
6	HSAC101	Communication Skill	1	0	0	1	AEC
7	HSAC102	Communication Skill Lab	0	0	2	1	AEC
8	HSVA101	Essence of Indian Knowledge and Tradition	1	0	0	1	CVAC
9	SNVA102	Sports/Yoga or NSS/NCC	0	0	4	2	CVAC
Total						20	

Category	**CC**	**MC**	**CVAC**	**MDC**	**AEC**	**SEC/Intern./ Diss.**	**Course Category**
Semester Credit	6	3	3	3	2	3	20
Cumulative Sum	6	3	3	3	2	3	20

Semester II (First Year)

Sl. No.	Course Code	Course Title	L	T	P	Course Credit	Course Category
1	PHCC201	Natural and Physical Sciences	3	0	0	3	CC
2	PHCC203	Fundamentals of Electronics	3	0	0	3	CC
3	PHMC201	Fundamentals of Physics II	3	0	0	3	MC
4	CSSE201	Programming for problem solving	2	0	0	2	SEC
5	CSSE202	Programming for problem solving Lab	0	0	4	2	SEC
6	CYMD201	General Chemistry	3	0	0	3	MDC
7	HSAC201	Advance Communication Skill	1	0	0	1	AEC
8	HSAC202	Advance Communication Skill Lab	0	0	2	1	AEC
9	UHVA201	Universal Human Values	3	0	0	3	CVAC
10	SNVA202	Sports/Yoga or NSS/NCC	0	0	4	2	CVAC
		Total				23	

Category	CC	MC	CVAC	MDC	AEC	SEC/Intern./ Diss.	Course Category
Semester Credit	6	3	5	3	2	4	23
Cumulative Sum	12	6	8	6	4	7	43

Semester III (Second Year)

Sl. No.	Course Code	Course Title	L	T	P	Course Credit	Course Category
1	PHCC301	Wave and Oscillations	3	0	0	3	CC
2	PHCC302	Wave and Oscillations Laboratory	0	0	2	1	CC
3	PHCC303	Optics I	3	0	0	3	CC
4	PHCC304	Optics Laboratory I	0	0	2	1	CC
5	MAMC301	Statistics and Probability	3	0	0	3	MC
6	CSSE301	Python and its applications	2	0	0	2	SEC
7	CSSE302	Python and its applications Lab	0	0	2	1	SEC
8	HSMD301	Principles of Economics/ Organizational Behaviour	3	0	0	3	MDC
9	HSAC301	English for Technical writing	2	0	0	2	AEC
10	HSAC302	English for Technical writing Lab	0	0	2	1	AEC
		Total				20	

Category	CC	MC	CVAC	MDC	AEC	SEC/Intern./ Disser.	Course Category
Semester Credit	8	3	0	3	3	3	20
Cumulative Sum	20	9	8	9	7	10	63

Semester IV (Second Year)

Sl. No.	Course Code	Course Title	L	T	P	Course Credit	Course Category
1	PHCC401	Mathematical Physics I	3	1	0	4	CC
2	PHCC403	Analog Electronics	3	1	0	4	CC
3	PHCC405	Classical Physics I	3	1	0	4	CC
4	PHCC402	General Physics Laboratory II	0	0	4	2	CC
5	MAMC401	Analytical Geometry	4	0	0	4	MC
6	HSAC401	Digital Communication Tools	1	0	0	1	AEC
7	HSAC402	Digital Communication Tools Lab	0	0	2	1	AEC
8	HSAU301	Indian Constitution (Audit)	2	0	0	0	MNC/AU
		Total				20	

Category	CC	MC	CVAC	MDC	AEC	SEC/Intern./ Disser.	Course Category
Semester Credit	14	4	0	0	2	0	20
Cumulative Sum	34	13	8	9	9	10	83

Semester V (Third Year)

Sl. No.	Course Code	Course Title	L	T	P	Course Credit	Course Category
1	PHCC501	Mathematical Physics II	3	1	0	4	CC
2	PHCC503	Solid State Physics I	3	1	0	4	CC
3	PHCC505	Electrodynamics I	3	1	0	4	CC
4	PHMC501	Radiation Physics	3	0	0	3	MC
5	CYMC501	Green Chemistry	3	0	0	3	MC
6	PHIN502	Internship	0	0	4	2	SEC/Inter
		Total				20	

Category	CC	MC	CVAC	MDC	AEC	SEC/Intern./ Disser.	Course Category
Semester Credit	12	6	0	0	0	2	20
Cumulative Sum	46	19	8	9	9	12	103

Semester VI (Third Year)

Sl. No.	Course Code	Course Title	L	T	P	Course Credit	Course Category
1	PHCC601	Atomic and Molecular Physics I	3	1	0	4	CC
2	PHCC603	Nuclear Physics	3	1	0	4	CC
3	PHCC605	Digital Electronics	3	1	0	4	CC
4	PHCC606	Electronics Lab	0	0	4	2	CC
5	ECMC601	Electromagnetic Field Theory	3	0	0	3	MC
6	MAMC601	Vector Calculus	3	0	0	3	MC
		Total				20	

Category	CC	MC	CVAC	MDC	AEC	SEC/Intern./ Disser.	Course Category
Semester Credit	14	6	0	0	0	0	20
Cumulative Sum	60	25	8	9	9	12	123

Semester VII (Fourth Year)

Sl. No.	Course Code	Course Title	L	T	P	Course Credit	Course Category
1	PHCC701	Mathematical & Computational Methods in Physics	3	1	0	4	CC
2	PHCC703	Quantum Mechanics I	3	1	0	4	CC
3	PHCC705	Classical Physics II	3	1	0	4	CC
4	PHCC702	General Physics Lab III	0	0	4	2	CC
5	PHMC701	Research Methodology	3	0	0	3	MC
6	ECMC701/ ECMC703	Antenna & Radar Engineering/ Optical Fiber Communication	3	0	0	3	MC
		Total				20	

Category	CC	MC	CVAC	MDC	AEC	SEC/Intern./Disser.	Course Category
Semester Credit	14	6	0	0	0	0	20
Cumulative Sum	74	31	8	9	9	12	143

Semester VIII (Fourth Year)

Sl. No.	Course Code	Course Title	L	T	P	Course Credit	Course Category
1	PHCC801/ MOCC801	Lasers Technology/MOOC	3	0	0	3	CC
2	PHCC803/ MOCC803	Energy Studies/MOOC	3	0	0	3	CC
3	PHCC805/ MOCC805	Modern Physics/MOOC	2	0	0	2	MC
4	PHPR802	Final year project (#)	0	0	24	12	Project
	OR						
	PHCC807	Electrodynamics II	3	1	0	4	CC
	PHCC809	Quantum Mechanics II	3	1	0	4	CC
	PHMC811	Statistical Mechanics	3	1	0	4	MC
Total						20	

Category	CC	MC	CVAC	MDC	AEC	SEC/Intern./Disser.	Course Category
Semester Credit	6	2	0	0	0	12	20
Cumulative Sum	80	33	8	9	9	24	163

Additional (3,3,2) Credits Major/Minor Course in place of MOOC course for the completion of 4-Years UG Degree (Honors).

#Additional (4,4,4) Credits Major Course in place of Project for the completion of 4-Years UG Degree (Honors). Final year project, student can perform at industry or at any other research laboratory.

Course Category (UGC)		First	Second	Third	Fourth	3 yrs	4 yrs
Core Course	**CC**	12	22	26	20	60	80
Mainor Course (Program elective and open elective)	**MC**	6	7	12	8	25	33
Multidisciplinary Course	**MDC**	6	3	0	0	9	9
Ability Enhancement Course	**AEC**	4	5	0	0	9	9
Skill Enhancement Course	**SEC**	7	3	0	0	10	10
Common Value-Added Course	**CVAC**	8	0	0	0	8	8
	Internship	0	0	2	0	2	2
	Research Project	0	0	0	12	0	12
	Total	**43**	**40**	**40**	**40**	**123**	**163**

6. ***Teaching-Learning Process:***

- The goal of the undergraduate physics program is to give students a solid theoretical foundation as well as practical insight into all facets of physics and research.
- It will assist students in acquiring an understanding of the significance of physics in various settings.
- The program covers both basic and advanced courses covering the conventional subfields of physics.
- ICT-enabled teaching-learning tools (PowerPoint presentations, audiovisual resources, e-resources, models, software, simulations, virtual labs, etc.) will be used in conjunction with the traditional chalk-and-talk method, laboratory work, projects, case studies, fieldwork, seminars, and hands-on training/workshops to deliver physics courses in a demanding, interesting, and inclusive way Students will be encouraged to carry out short term projects and participate in industrial and institutional visits and outreach programs.
- Complementing the theoretical concepts taught in the classroom, the laboratory training involves practical experience with contemporary instruments, modeling, error estimation, computational data processing, and laboratory safety protocols.
- Whenever feasible, a variety of pedagogies will be employed, including inquiry-based learning, project-based learning, experiential learning, participatory learning, and blended and flipped learning, which integrates ICT pedagogy.
- Group projects will be promoted to help students improve their interpersonal abilities, such as cooperation and communication.
- Students will establish a solid basis for a prosperous career in academia, industry, research, entrepreneurship, and community service through their conscientious and active involvement in industrial visits, internships, academic projects, and dissertations.

7. ***Assessment Methods:***

The key objective of the evaluation will be to measure the course's learning outcomes about the overall objectives of improving foundational theoretical knowledge, research, and practical laboratory abilities. Assessment will be based on continuous evaluation of Class Tests (CT), Quiz, Assignments, and end semester examinations of North Eastern Regional Institute of Science and Technology (NERIST), Arunachal Pradesh.

- ***Internal Assessment or Continuous Evaluation:***

Throughout a semester, Class Tests (CT), Quiz, and Assignments will be used to evaluate students' understanding of the various learning outcomes outlined in the syllabus. Each theory paper and practical paper will have 10 and 20 marks for internal assessment, respectively. The critical analysis of internal assessment or 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.

- ***End Semester University Examinations:***

The summative end-semester university examinations will be conducted for both theory and practical courses. Besides internal assessment, each theory paper and each practical paper will be of 100 marks for end semester examination of the institute.

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List of Courses

Note: **Every theory/practical subject has 3 credits.**

List of Core Courses

Semester I

PHCC101: Electricity and Magnetism
PHCC103: Mechanics

Semester II

PHCC201: Natural and Physical Sciences
PHCC203: Fundamental of Electronics

Semester III

PHCC301: Waves and Oscillation
PHCC302: Waves and Oscillation Lab
PHCC303: Optics I
PHCC304: Optics Lab I

Semester IV

PHCC401: Mathematical Physics
PHCC403: Analog Electronics
PHCC405: Classical Physics I
PHCC402: General Physics Lab II

Semester V

PHCC501: Mathematical Physics-II
PHCC503: Solid State Physics-I
PHCC505: Electrodynamics I

Semester VI

PHCC601: Atomic and Molecular Physics-I
PHCC603: Nuclear Physics I
PHCC605: Digital Electronics
PHCC606: Digital Electronics Lab

Semester VII

PHCC701: Mathematical & Computational methods in Physics
PHCC703: Quantum Mechanics I
PHCC705: Classical Physics II
PHCC702: General Physics Lab-III

Semester VIII

PHCC801/MOCC801: Laser Technology/MOOC
PHCC803/ MOCC803: Energy Studies/MOOC
PHCC805/ MOCC805: Modern Physics/MOOC
PHCC807: Electrodynamics II
PHCC809: Quantum Mechanics II
PHCC811: Statistical Mechanics

List of Minor (MN) Courses:

Semester-I: (3 Credit)

PHMC101: Fundamentals of Physics I

Semester-II: (03 Credit)

PHMC201: Fundamental of Physics II

Semester-III : (3 Credits)

MAMC301: Statistics & Probability

Semester-IV : (3 Credits)

MAMC401: Analytical Geometry

Semester-V : (3 Credits) (T)

CYMC501: Green Chemistry

Semester-VI : (6 Credits) (T)

MAMC601: Vector Calculus
ECMC601: Electomagnetic Field Theory

Semester-VII : (6 Credits) (T)

PHMC701: Research Methodology
ECMC701/ECMC703: Antenna & Radar Engineering/ Optical Fiber Communication

List of Ability Enhance Courses (AEC):

Semester-I:

HSAC101: Communication Skill
HSAC102: Communication Skill Lab

Semester-II:

HSAC201: Advance Communication Skill
HSAC202: Advance Communication Skill Lab

Semester-III:

HSAC301: English for Technical Writing
HSAC302: English for Technical Writing Lab

Semester-IV:

HSAC401: Digital Communication Tools
HSAC402: Digital Communication Tools Lab

List of Co-Curricular Courses (CC):

Semester-I: Select any one

Select from University Bucket e.g. NSS, NCC, Yoga, etc……

Semester-II: Select any one

Select from University Bucket e.g. NSS, NCC, Yoga, etc……

Syllabus of Courses

Semester I (Core Course)

PHCC101: Electricity and Magnetism (Credits:03)

Course Objectives:

This course aims to introduce the Physics of Electricity and Magnetism to the students.
Objectives are.

- To Study the basic concepts of Electricity and Magnetism.
- To Study the basic concepts of Magnetostatics.
- To Study the basic concepts of Magnetism.
- To study the basic concepts of Electromagnetic Induction and dielectrics.

Course Outcomes (CO):

After completion of the course, students will be able to:

CO1: Explain the basic concept of Coulomb's law and Gauss's law, the principle of a capacitor, etc.

CO2: Describe the basic concept of magnetic flux, magnetic induction, magnetic field due to current carrying conductor, etc.

CO3: Outline the basic concepts of magnetism.

CO4: Explain the basics of electromagnetic induction, dielectric materials, etc.

Course Code: PHCC101	***Electricity and Magnetism***	***L-T-P:C 3-0-0: 3***
Module I	**Electrostatics:** Coulomb's inverse square law, Electric Field and potentials, Field due to a uniformly charged sphere, Derivations of Poisson and Laplace Equations, Gauss Theorem, and its applications: for an Infinite Line of Charge, a Charged Cylindrical Conductor, an Infinite Sheet of Charge and Two Parallel Charged Sheets, Electric dipole, Field and potential due to an electric dipole, Principle of a capacitor-Capacity of a spherical and cylindrical capacitor, Energy stored in a capacitor, Loss of energy due to sharing of charges.	*12 hours*
Module II	**Magnetostatics:** Magnetic Effect of Currents, Magnetic Field, Magnetic force on a current, Magnetic Flux, Magnetic Induction, Biot-Savart's Law: a Straight Current Carrying Conductor. Magnetic Dipole, Magnetomotive force, Lorentz Force, Vector and Scalar Magnetic potentials, Ampere's Circuital law and its applications to calculate magnetic field due to wire carrying current and solenoid.	*10 hours*
Module III	**Magnetism:** Intensity of magnetization, Susceptibility, Types of magnetic materials, Properties para, dia and ferromagnetic materials, Cycle of magnetization, Curie temperature, Hysteresis, B-H curve, application of BH curve–Magnetic energy per unit volume.	*10 hours*

Module IV	**Electromagnetic Induction:** Laws of electromagnetic induction, Faraday's laws, and Lenz's Law, Self and mutual induction, Self-inductance of a solenoid, and mutual induction of a pair of solenoids, Vector potential in varying Magnetic fields, Skin effect, Motion of Electron in changing magnetic field, induced magnetic field, Displacement current, Maxwell's equations, Electromagnetic waves in free space, Theory and working of moving coil ballistic galvanometer. **Dielectrics:** Dielectric constant, polarization, Electronic, Atomic or ionic polarization, polarisation charges, Electrostatic equation with dielectrics, Field, force, and energy in Dielectrics.	*10 hours*

Learning Resources:

Text Books:

1. Electricity and Magnetism, Brijlal and Subramaniyam, S. Chand & Co. 2020
2. Electricity and Magnetism, R. Murugesan, S. Chand & Co.2019
3. Electricity and Magnetism. By D C Tayal, Himalaya Publishing House. 2024
4. Electromagnetism for Engineers: An Introductory Course, P. Hammond, oxford science publication, 4^{th} edition ,1997
5. Magnetism and Magnetic Materials, J.M.D. Coey, Cambridge University Press. 2010

Reference Books:

1. Electricity and Magnetism, Narayana Moorthy and Nagaratnam, NPC, Chennai.
2. Magnetic Materials: Fundamentals and Applications, Nicola A. Spaldin, Cambridge University Press, 2^{nd} edition, 2010.

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PHCC103: Mechanics (Credits:03)

Course Objectives:

This course aims to introduce the Physics of Mechanics to the students.
Objectives are.

- To Study the basic concepts of Fundamentals of Dynamics.
- To Study the basic concepts of Fluid Mechanics.
- To Study the basic concepts of Rigid Body Dynamics.
- To study the basic concepts of Simple harmonic motions.

Course Outcomes (CO):

After completion of the course, students will be able to:

CO1: Outline the basic concept of laws of motion, the concept of conservation of energy, momentum, angular momentum, planetary motion, etc.

CO2: Explain the basic properties of matters such as viscosity and surface tension and the determination of various parameters associated with it.

CO3: Define the concepts of rigid body and its related dynamics.

CO4: Analyze the basics of harmonic motion.

Course Code: PHCC103	*Mechanics*	*L-T-P:C 3-0-0:3*
Module I	**Fundamental of Dynamics:** Reference Frames, Newton's Laws of Motion and its limitations, Invariance of Newton's law under Galilean transformations, Fictitious forces, Effects of Centrifugal and, Coriolis forces due to earth's rotation. Significance of conservation laws, Law of conservation of energy, Concepts of Work, Power, and Energy, Conservative forces, Conservative force as the negative gradient of potential energy. Non-conservative forces–General law of conservation of energy, Conservation of momentum (linear and angular), Motion of a planet in an elliptical orbit around the sun. Potential Energy and Energy diagram. Kepler's laws of planetary motion. Concept of elastic and inelastic collisions. Derivation of final velocities in case of elastic collision and inelastic collision in mass and the laboratory frame of reference.	*14 hours*
Module II	**Fluid Mechanics:** Surface tension, Surface energy, the relation between surface tension and surface energy, the pressure difference across the curved surface, excess pressure inside the spherical liquid drop, and contact angle. Determination of surface tension by Ferguson method. Applications of surface tension. Effect of temperature, and impurity on surface tension. Viscosity, Streamline flow, turbulent flow, equation of continuity, Bernoulli's Theorem, determination of coefficient of viscosity by Poisulle's method, Stoke's method (with derivation). Effect of temperature and pressure on viscosity.	*12 hours*

Module III	**Rigid Body Dynamics**: Rigid body-translational and rotational motion, Torque, Angular impulse, Radius of gyration, General theorems on moment of inertia, Derivation of expressions for moment of inertia: (i) rectangular lamina (ii) circular disc. Euler's equations of motion, Moment of inertia of a flywheel.	*6 hours*
Module IV	**Simple Harmonic Motion (SHM):** Periodic and Harmonic Motion, Harmonic oscillator, Differential equation of SHM, Phase relationship between displacement, velocity, and acceleration of SH Oscillator, Energy of a harmonic oscillator, Some examples of S.H.M.: simple pendulum, bar pendulum. Damped harmonic motion – Damping (Frictional effects), over-damped, critically damped, and lightly-damped oscillators; Power dissipation, Quality factor, examples of damped harmonic oscillators.	*10 hours*

Learning Resources:

Text Books:

1. Mechanics, S P Taneja, R Chand & Co , 3rd edition, 2019
2. Mechanics, D.S. Mathur, S. Chand and Company Limited. 2000
3. Properties of Matter , D.S. Mathur, S. Chand and Company Limited.2010
4. An introduction to mechanics, D. Kleppner, R.J. Kolenkow, Cambridge university press, 2nd edition,2021
5. Mechanics: Berkeley Physics, vol.1, C. Kittel, W. Knight, et.al. , McGraw-Hill education ,2nd edition,2017

Reference Books:

1. Analytical Mechanics, G.R. Fowles and G.L. Cassiday., Brooks/cole,1993
2. Engineering Fluid Mechanics, Dr. KL Kumar, S. Chand, 2010

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Semester I (Minor Course)

PHMC101: Fundamental of Physics I (Credits:03)

Course Objectives:

This course aims to introduce the Physics of Mechanics to the students.
Objectives are.

- To Study the basic concepts of Fundamentals of Dynamics.
- To Study the basic concepts of Fluid Mechanics.
- To Study the basic concepts of Rigid Body Dynamics.
- To study the basic concepts of Simple harmonic motions.

Course Outcomes (CO):

After completion of the course, students will be able to:

CO1: Explain the basic concept of laws of motion, center of mass, torque, conservation of energy, and momentum.

CO2: identify the basic relation between pressure and force; calculate pressure as a function of depth in liquids, use the continuity equation and Bernoulli's equation to solve problems involving fluid dynamics.

CO3: Describe the concepts of blackbody radiation, wave-particle duality, inadequacy of classical mechanics, etc.

CO4: Analyze the basics of harmonic motions.

Course Code: PHMC101	***Fundamental of Physics I***	***L-T-P:C 3-0-0: 3***
Module I	**Laws of Motion:** Newton's Laws, Frames of reference, Galilean Transformation, Dynamics of a system of particles, Centre of Mass. Momentum and Energy: Conservation of momentum, Work and energy, Conservation of energy. Rotational motion: Angular velocity and angular momentum, Torque, Conservation of angular momentum. Moment of Inertia, Radius of gyration, Kinetic Energy of Rotation, Rolling Motion on an inclined plane.	*15 Hours*
Module II	**Fluid Statics:** Fluids, Density, and Pressure, Variation of pressure with depth, Pressure gauges, Archimedes' principle, surface tension, contact angle, and capillarity; Fluid dynamics: Equation of continuity, Bernoulli's equation and its applications, Viscosity, Poiseuille's law, Stoke's law, Reynolds number, Viscous force and Effect of Temperature. Surface Tension, Surface Energy, and angle of contact.	*12 hours*
Module III	**Modern Physics:** Inadequacy of classical physics, Black body Radiation, Planck's quantum hypothesis, Planck's constant, Photoelectric effect, and Compton scattering -light as a collection of photons. De Broglie wavelength. Wave-particle duality. Wave description of particles by wave packets. Group and Phase velocities and the relation between them.	*6 hours*

Module IV	**Oscillations:** Simple Harmonic Oscillator: Kinetic energy, potential energy, Differential equation of simple harmonic motion and its solution, Damped Oscillator: underdamped, overdamped, and critically damped oscillator, Forced oscillations: Transient and steady states, Resonance, Sharpness of resonance, Power dissipation and Quality Factor, Compound pendulum.	*10 hours*

Learning Resources:

Text Books:

1. Mechanics, D.S. Mathur, S. Chand and Company Limited ,2000
2. Properties of Matter ,D.S. Mathur, S. Chand and Company Limited ,2010
3. An introduction to mechanics, D. Kleppner, R.J. Kolenkow, Cambridge university press, 2nd edition,2021
4. Surface Tension by C. V. Boys, https://www.gutenberg.org/ebooks/33370
5. Concepts of Modern Physics, A Beiser ,Medtech science, 2024

Reference Books:

1. Principles of Physics. D. Halliday, J. Walker, and Robert Resnick, Wiley,10th edition 2015
2. Engineering Fluid Mechanics, Dr. KL Kumar, S. Chand ,2010
3. Physics for Scientists and Engineers with Modern Physics, Raymond A. Serway/John W. Jewett , Cengage Learning India Pvt. Ltd. 10th edition ,2023

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Semester I (Practical)

PHSE101: *General Physics Lab I (Credits:03)*

Course Objectives:

This course introduces the practical related to Mechanics and Physics Principles and its applications.

Course Outcomes (CO):

The students should able to explain the concepts of diffraction, refraction, and dispersion by using Prism, grating, and rectangular slabs.

Complete any seven practical's from the given experiments:

Sl. No.	Title of the experiments
1	*To study the use of various measuring instruments* *1. Vernier caliper 2. Micrometer screw gauge 3. Spherometer.*
2	*To determine an acceleration due to gravity "g" by using a bar pendulum*
3	*To determine the coefficient of viscosity by using Stoke's method.*
4	*To determine the moment of inertia of a flywheel.*
5	*To determine the Planck's constant.*
6	*To determine the surface tension using the capillary rise method*
7	*To determine the spring constant of a spring hence determine acceleration due to gravity "g".*
8	*To determine the dispersive power of the material of a prism.*
9	*To determine the Cauchy's constants a and b of the material of a prism.*
10	*To trace the course of different rays of light through a rectangular glass slab.*

Learning Resources:

Text Books:

1. Engineering Practical Physics, S.Panigrahi and B. Mallick, CENGAGE learning,2015)
2. B.Sc. Practical Physics, C.L. Arora. S.Chand ,2010
3. Physics in laboratory, Electricity & Magnetism, Wave & Optics, Supriya Das and Mili Das, Santra Publication Pvt Ltd ,1st edition 2020

Online Resources:

https://www.vlab.co.in/participating-institute-amrita-vishwa-vidyapeetham

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Semester II (Core Course)

PHCC201: Natural and Physical Sciences (Credits:03)

Course Objectives:

This course aims to develop an understanding of the workings of the universe and to extend the body of scientific knowledge.

Objectives are.

- To Study the basic concepts of Physics in Earth's Atmosphere.
- To Study the basic concepts of Physics in the Human Body and Sports.
- To Study the basic concepts of Physics in Technology.
- To study the basic concepts of Physics in the Universe.

Course Outcomes (CO):

After completion of the course, students will be able to:

CO1: Outline the basic concept of physics on a deeper level and its uses to navigate everyday life.

CO2: Describe the basic principle working principle of human eyes, and ears as well as the basic use of physics in sports.

CO3: Interpret the role of physics in day-to-day technology.

CO4: Explain the concept of basic astrophysics.

Course Code: PHCC201	***Natural and Physical Sciences***	***L-T-P:C 3-0-0: 3***
Module I	**Physics in Earth's Atmosphere:** Sun, Earth's atmosphere as an ideal gas; Pressure, temperature, and density, Pascal's Law and Archimedes' Principle, Corioli's acceleration and weather systems, Rayleigh scattering, the red sunset, Reflection, refraction, and dispersion of light, Total internal reflection, Rainbow.	*12 hours*
Module II	**Physics in Human Body and Sports:** The eyes as an optical instrument, Vision defects, Rayleigh criterion and resolving power, Sound waves and hearing, Sound intensity, Decibel scale, Energy budget, and temperature control. Physics in Sports: The Sweet Spot, Dynamics of rotating objects, Motion of a spinning ball, Running, Jumping and pole vaulting, Continuity and Bernoulli equations, Turbulence and drag	*12 hours*
Module III	**Physics in Technology:** Microwave ovens, Rockets, Lorentz force, Global Positioning System, CCDs, Lasers, Displays, Optical recording, CD, DVD Player, Tape records, Electric motors, Hybrid car, Telescope, Microscope, Projector, etc.	*8 hours*
Module IV	**Physics in the Universe:** Solar system, Kepler's laws of Planetary motion, the life cycle of a star, white dwarf, orbital motion, The Big Bang, Dark matter and dark energy, Cosmic microwave background, Gravitational waves, Black holes, Wormholes.	*10 hours*

Learning Resources:

Text Books:

1. Concepts of Physics, H. C. Verma, Bharati Bhawan (publishers and distributors), 2024
2. Sears and Zemansky's University Physics ,pearson,10th edition,1999
3. Electricity and Magnetism, R Murugeshan ,_S Chand Publishing,2019
4. Physics in Daily Life, Jo Hermans, EDP Sciences ,2012
5. Fundamentals of Physics: The Universe Unveiled, J. K. Kushwaha ,2022

Reference Books:

1. Optics ,E. Hecht, Pearson Education Limited,2001
2. Advanced Level Physics, Nelkon & Parker, **CBS,7th edition 1995**
3. How Things Work, The Physics of Everyday Life, Louis A. Bloomfield, Wiley,4th edition 2009.

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PHCC203: *Fundamental of Electronics (Credits:03)*

Course Objectives:

This course aims to introduce an understanding of electronics, elements, and their functionality.
Objectives are.

- To Study the basic concepts of the Basic Resistive circuit.
- To Study the basic concepts of Semiconductors.
- To Study the basic concepts of Bipolar junction transistors.
- To study the basic concepts of Operational amplifiers.

Course Outcomes (CO):

After completion of the course, students will be able to:

CO1: Explain the basic concept of current voltage, resistance, and some theorems and laws of electronics.

CO2: Elucidate the basic properties of semiconductors and their applications as diodes and rectifiers.

CO3: Describe the concepts of bipolar junction transistors and their application as amplifiers.

CO4: classify the basics of Operational Amplifier as summer, integrator, and differentiator.

Course Code: PHCC203	***Fundamental of Electronics***	***L-T-P:C 3-0-0: 3***
Module I	**Basic Resistive circuit:** Ohm's law, Resistors in parallel and series combination, DC voltage and current sources: ideal and non-ideal cases, Kirchoff's current and voltage law, Voltage divider circuit, Current divider circuit, source transformation-voltage source to current source and current source to voltage source, Thevenin's Theorem. Norton's Theorem, Reciprocity Theorem, Maximum Power Transfer Theorem.	*11 hours*
Module II	**Semiconductors:** Types of Semiconductors, doping, the effect of temperature on semiconductors, PN junction diode: unbiased PN junction, Forward and reversed biased condition, Formation of Depletion Layer, Diode Equation, and I-V characteristics. Idea of static and dynamic resistance, DC load line analysis, Quiescent (Q) point. Zener diode, Reverse saturation current, Zener, and avalanche breakdown, Zener diode as a voltage regulator. Diode as Rectifiers- Half wave rectifiers, Full wave rectifiers (center tapped and bridge), circuit diagrams, working and waveforms, ripple factor, and efficiency. Filter-Shunt capacitor filter, its role in power supply, output waveform, and working.	*13 hours*
Module III	**Bipolar Junction Transistor:** NPN and PNP transistors, 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. 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. Two-stage RC Coupled Amplifier and its Frequency Response. Concept of feedback, negative and positive feedback, advantages of negative feedback (Qualitative only)	*11 hours*

Module IV	**Operational Amplifier (Op-amps)**: Ideal Op-amp, Differential amplifier: differential and common mode operation common mode rejection ratio (CMRR), Practical op-amp circuits: inverting amplifier, non-inverting amplifier, weighted summer, integrator, differentiator.	*8 hours*

Learning Resources:

Text Books:

1. A Textbook of Applied Electronics, R. S. Sedha, S.Chand & Co. 2019
2. Basic Electronics: Principles and Applications, C. Saha, A. Halder, D. Ganguly, Cambridge University Press , 1st edition,2018
3. Basic Electronics: Solid State, B. L. Theraja, S. Chand & Co. 2006
4. Electronics Fundamentals and Applications, P. C. Chattopadhyay, D. Rakshit, New age international private limited, 16th edition, 2020
5. Electronics: Principles and Applications, C. A. Schuler, MacGraw Hill Education. 5th edition,1999

Reference Books:

1. Basic Electronics (Includes Solved Problems and MCQs), B. Somanathan Nair, I. K. International Publishing House pvt.Ltd, 2013
2. Electronic Principles, A. Malvino, D. J. Bates, MacGraw Hill Education, 7th edition,2017
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Semester II (Minor Course)

***PHMC201:** Fundamental of Physics II (Credits:03)*

Course Objectives:

This course aims to introduce the Physics of Mechanics to the students.
Objectives are.

- To Study the basic concepts of Thermodynamics.
- To Study the basic concepts of Basic Electronics.
- To Study the basic concepts of Solid-State Physics.
- To study the basic concepts of Electromagnetics.

Course Outcomes (CO):

After completion of the course, students will be able to:

CO1: Explain the basic concept of Thermodynamics and the laws of thermodynamics.

CO2: apply the basics of semiconductors and its applications.

CO3: Outline the fundamentals of solids and understand the concept of superconductors

CO4: Explain the basics of Maxwell equations, electrostatics, equation of continuity, etc.

Course Code: PHMC201	*Fundamental of Physics II*	*L-T-P:C 3-0-0: 3*
Module I	**Thermodynamics:** Thermodynamic systems, Concepts of Heat and Temperature, Macroscopic and Microscopic Variables, Laws of thermodynamics, Carnot engine and its efficiency, Carnot's cycle, Carnot theorem, Concept of Entropy, Reversible and irreversible processes, Clausius-Clapeyron's equation, Specific heat of saturated vapor, Clausius theorem, Clausius inequality.	*15 hours*
Module II	**Basic Electronics:** Semiconductors and their Types, Semiconductor Diode: The ideal Diode, Forward and Reverse Bias, V-I characteristics of Diode, Half-Wave and Full-Wave Rectifier Circuits, Zener Diode, Transistors: Bipolar Junction Transistors: p-n-p and n-p-n transistors and their working principles, Transistor currents, input and output characteristics of Common base configuration, Common Emitter configuration, transistor as a switch.	*12 hours*
Module III	**Solid State Physics:** Lattice and Translation vectors, Unit cell, Basis, Symmetry operations, point groups, space groups, types of lattices, Miller indices, Reciprocal Lattice, Brillouin zones, Bonding in Solids, Dielectric Properties of Materials, Magnetic Properties of Matter, Superconducting Materials: Temperature dependence of resistivity in superconducting materials, Effect of magnetic field (Meissner effect), Type-I and Type II superconductors.	*8 hours*

Module IV	**Electromagnetics:** Overview of Electrostatics, Time-Varying Electromagnetic Fields, Poisson's and Laplace's Equations, Displacement Current, Maxwell's Equations, Equation of continuity, EM- Wave equation and its propagation characteristics in free space and in conducting media, Poynting theorem and Poynting vectors.	*8 hours*

Learning Resources:

Text Books:

1. Engineering Physics: B.K. Pandey and S. Chaturvedi, Cengage Learning India Pvt.Ltd,2021
2. Mechanics, D.S. Mathur, S. Chand and Company Limited ,2000
3. Surface Tension by C. V. Boys, https://www.gutenberg.org/ebooks/33370
4. Concepts of Modern Physics: A Beiser , McGraw Hill, 6th ed 2003
5. A Textbook of Applied Electronics, R. S. Sedha, S.Chand & Co ,2008

Reference Books:

1. Fundamentals of Physics. D. Halliday, J. Walker, and Robert Resnick, Wiley. 2013
2. Physics for Scientists and Engineers with Modern Physics, Serway ,CENGAGE Learnings. 9th ed,2017

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First Year **(Exit Course)**

PHEX101: *Experimental Skills in Physics (Credits:02)*

Course Objectives:

This course aims to introduce an understanding of instruments' working principles and their physical applications. To impart knowledge about the measurement of physical quantity and its analysis of the practical related to mechanics and physics principles and their applications.

Course Outcomes (CO):

Upon completion of the course, the students will be able to analyze the working principles of various measuring instruments and acquire the scientific information of various physical and electrical instruments used in physics practicals. Students will be able to identify the errors in the instrument.

Course Content- *(Any **12** experiments + **3** Experimental Activities)*

List of Experiments:

- *To plot the graph of distance vs time, and velocity vs time by given data and write the conclusion.*
- *To determine the least count of instruments like Vernier Calliper, Micrometer Screw Gauge, Travelling Microscope, Spectrometer, etc.*
- *To determine the inner and outer radius of the given pipe by using Vernier Calliper and determine the diameter of the pin by using a micrometer screw gauge.*
- *To determine the radius of curvature of the lenses by using a spherometer.*
- *To measure AC, and DC voltage of signals by using CRO.*
- *To observe the loading effect of a multimeter while measuring voltage across a low resistance and high resistance.*
- *To measure the 'Q' factor using an LCR circuit.*
- *Study of diode characteristics.*
- *To measure the frequency of different signals by using CRO.*
- *To check and repair the fault of the DC circuit.*
- *To study how to plot the graph of any single observation on graph paper and how to observe the readings from graphs (e.g. I-V, V-T, I-T, etc.)*
- *Verification of formula for voltage divider theorem*
- *Verification of formula for current divider theorem.*
- *To measure the viscosity of a liquid.*
- *To study and repair of Power supply.*
- *Skill of soldering in Printed circuit board.*
- *Skill to use a breadboard, hood up wire, laboratory experiment.*

Additional Activities to be conducted related to the subject (Any-3)

1. Mini Projects with report.
2. Industrial /Research organization /Working organization /Field visit with report.

3. Any one computer-aided demonstrations.
4. Demonstrations -Any one demonstrations.

** Students have to perform 12 experiments and participate in an additional three activities equivalent to 3 experiments with 12 experiments. Total laboratory work with additional activities should be 15 experiments.*

**Students have to prepare a notebook with all laboratory experiments performed in the semester and have to submit it to the department before the examination.*

Learning Resources:

Text Books:

1. Digital Circuits and systems , K. R. Venugopal, Tata McGraw Hill Publishing Company Ltd. 2011
2. Electronic circuits: Handbook of design and applications , U. Tietze, Ch. Schenk , Springer-Verlag Berlin and Heidelberg Gmb, 2008
3. A textbook in Electrical Technology ,B. L. Thareja, S. Chand and Co. (Volume III) Publishers. 2008
4. BSc Practical Physics, H. Singh, S Chand Publishers ,2022
5. Advanced Practical Physics, B.L. Worsnop and H. T. Flint, Khosla Publishing House, New Delhi 2021
6. B.Sc. Practical Physics, C. L. Arora, S Chand & Company, New Delhi. 2010

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First Year (Exit Course)

PHEX103: Basic Lab Electric Devices and Circuits (Credits:02)

Course Objectives:

This course aims to introduce Electric circuits and Networks to contribute the knowledge of electric elements and their uses, and also awareness of Instrumentation and its Industrial Application.

Course Outcomes (CO):

CO1: Describe basic concepts of electric elements and their functions.

CO2: Provide adequate knowledge about the Industrial applications of electric instruments.

CO3: Provide adequate knowledge about its applications.

CO4: Students can study Electrical Engineering.

Course Content- *(Any 12 experiments + 3 Experimental Activities)*

List of Experiments:

- To study CRO.
- To study V-I Characteristics of the p-n Junction Diode.
- To study V-I Characteristics of Zener Diode and Zener Regulator Characteristics.
- To study V-I Characteristics of LED.
- To study Half-Wave Rectifier with and without Filter.
- To study Full-Wave Rectifier with and without Filter.
- To study Bridge-Wave Rectifier with and without Filter
- To study output characteristics of transistors in CB mode.
- To study output characteristics of transistors in CE mode.
- To measure h-Parameters of CB Configuration.
- To study a comparison of the performance of Self Bias and Fixed Bias Circuits.
- To study applications of Diodes.
- To study characteristics of Thermistor.
- To study oscillators.
- To study simple power supply.
- To study introduction to Integrated Circuits (IC).

Additional Activities to be conducted related to the subject (Any-3)

1. Mini Projects with report.
2. Industrial /Research organization /Working organization /Field visit with the report.
3. Computer-aided demonstrations.
4. Demonstrations -Any one demonstrations.

***Students have to perform 12 experiments and participate in an additional three activities equivalent to 3 experiments with 12 experiments. Total laboratory work with additional activities should be 15 experiments.**

**Students have to prepare a notebook with all laboratory experiments performed in the semester and have to submit it to the department before the examination.*

Learning Resources:

Text Books:

1) Basic Electronics and Linear Circuit ,NN Bhargava, Kulshreshta and SC Gupta, Tata McGraw Hill Education Pvt Ltd.2017
2) Principles of Electrical and Electronics Engineering ,VK Mehta; S Chand and Co. 2015
3) Electrical and Electronics Engineering ,SK Bhattacharya, Pearson Education 2022
4) Principles of Electronics ,SK Bhattacharya and Renu Vig, SK Kataria & Sons. 2007
5) Electronics Devices and Circuits ,Millman and Halkias; McGraw Hill ,2017

*Students exiting the program after securing **40 credits** will be awarded **UG Certificate** in the relevant **Discipline/Subjec**t provided. They will earn **4 additional credits** in (exit course) work based vocational courses offered during the summer term or internship/Apprenticeship in addition to **6 credits** from skill-based courses during the first and second semesters.*

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Semester III (Core Course)

PHCC301: Waves and Oscillations (Credits:03)

Course Objectives:

This course aims to introduce the Physics of Waves and Oscillations to the students.
Objectives are.

- Revisiting and building upon foundational concepts of waves and oscillations learnt in school.
- Starting with understanding free oscillations and how harmonic motions superpose.
- Progressing to the physics behind damped and forced oscillations.
- Introducing the ideas of coupled oscillators and normal modes of oscillation.

Course Outcomes (CO):

After completion of the course, students will be able to:

CO1: Explain simple harmonic motion

CO2: Illustrate the superposition of N collinear harmonic oscillations

CO3: Illustrate the superposition of two perpendicular harmonic oscillations

CO4: Classify free, damped, and forced oscillations.

CO5: Identify coupled oscillators and normal modes of oscillations.

Course Code: PHCC301	***Waves and Oscillations***	***L-T-P:C 3-0-0: 3***
Module I	**Simple Harmonic Motion:** Differential equation of simple harmonic oscillator, its solution and characteristics, energy in simple harmonic motion, linearity and superposition principle, rotating vector representation of simple harmonic oscillation, motion of simple and compound pendulum (Bar and Kater's pendulum), loaded spring. Superposition of N collinear harmonic oscillations with (1) equal phase differences and (2) equal frequency differences, Beats Superposition of two perpendicular harmonic oscillations: Graphical and Analytical Methods. Lissajous Figures with equal and unequal frequencies, the effect of variation of phase	*11 hours*
Module II	**Damped Oscillations:** Equation of motion, dead beat motion, critically damped system, lightly damped system: relaxation time, logarithmic decrement, quality factor Forced Oscillations: Equation of motion, complete solution, steady state solution, resonance, sharpness of resonance, power dissipation, quality factor. Coupled oscillators, normal coordinates, and normal modes, energy relation and energy transfer, di-atomic molecules, representation of a general solution as a linear sum of normal modes, normal modes of N coupled oscillators.	*11 hours*
Module III	**Superposition of Two Harmonic Waves:** Standing (Stationary) Waves in a String: Fixed and Free Ends. Analytical Treatment. Phase and Group Velocities. Changes with Position and Time. Energy of Vibrating String. Transfer of Energy. Normal Modes of Stretched Strings. Longitudinal Standing Waves and Normal Modes. Open and Closed Pipes. Superposition of N Harmonic Waves.	*10 hours*

Module IV	**Wave Motion:** One-dimensional plane wave, classical wave equation, standing wave on a stretched string (both ends fixed), normal modes. Plane and Spherical Waves. Longitudinal and Transverse Waves. Plane Progressive (Travelling) Waves. Wave Equation. Particle and Wave Velocities. Pressure of a Longitudinal Wave. Energy Transport. Intensity of Wave.	*10 hours*

Learning Resources:

Text Books:

1. Vibrations and Waves, A. P. French, CBS Pub. and Dist., First Edition,1987.
2. The Physics of Waves and Oscillations, N.K. Bajaj, First Edition, Tata McGraw-Hill, 1988.
3. Fundamentals of Waves and Oscillations, K. Uno Ingard, Cambridge University Press, 1988.
4. An Introduction to Mechanics, Daniel Kleppner, Robert J. Kolenkow, Second Edition, Cambridge University Press, 2013.
5. Waves: BERKELEY PHYSICS COURSE by Franks Crawford, Tata McGrawHill Education, 2017.

Reference Books:

1.Fundamentals of Physics, Resnick, Halliday and Walker, Wiley,10^{th} Edition, 2013.

2.University Physics, H. D. Young, R. A. Freedman, Pearson Education,14^{th} Edition, 2015.

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Semester III (Core Course)

PHCC303: Optics I (Credits:03)

Course Objectives:

This course aims to introduce the Physics of Optics.

Objectives are.

- To provide students with a solid understanding of Fermat's principle and its applications in optical systems.
- To equip students with a thorough understanding of wave theory and interference of a light.
- To provide students with an in-depth understanding of Haidinger fringes and fringes of equal inclination.
- To provide a comprehensive understanding of laser systems

Course Outcomes (CO):

After completion of the course, students will be able to:

CO1: Explain Fermat's Principle

CO2: Illustrate the phenomenon of interference of light

CO3: Analyze the principles behind Haidinger fringes and fringes of equal inclination leads to the ability to apply interferometric techniques.

CO4: Outline the basic ideas of LASER

Course Code: PHCC303	***Optics I***	***L-T-P:C 3-0-0: 3***
Module I	**Fermat's principle:** Principle of extremum path, the aplanatic points of a sphere and other applications. General theory of image formation: cardinal points of an optical system, general relationships. Thick lens and lens combination, Lagrange equation magnification, telescopic combinations, telephoto lenses and eyepieces.	*11 hours*
Module II	**Wave Theory:** 3D wave equation, Huygen's Principle, Laws of reflection and Refraction from wave theory and total internal reflection of light. **Interference of a light:** The principle of superpositions, two-slit interference, coherence requirement for the sources, optical path retardations, lateral shift of fringes, Rayleigh refractometer and other applications. Localized fringes; thin films, applications for precision measurements for displacements.	*12 hours*
Module III	**Haidinger fringes:** Fringes of equal inclination. Michelson interferometer, its application for precision determination of wavelength, wavelength difference and the width of spectral lines. Twymann-Green interferometer and its uses. Intensity distribution in multiple beam interference, Tolansky fringes, Fabry-Perot interferometer and etalon.	*11 hours*
Module IV	**Laser system:** Einstein's A and B coefficients, Spontaneous and induced emissions, conditions for laser action, population inversion. Types of Lasers, Characteristics and application of Lasers	*8 hours*

Learning Resources:

Text Books:

1. Optics, A K Ghatak, McGraw Hill India, Eighth Edition, 2024.
2. Optics and Atomic Physics, D P Khandelwal, Himalaya Publishing House, 2015.
3. Manchester Physics series; Optics, F Smith and J H Thomson, English Language Book Society and John Wiley, Second Edition, 1988.
4. Optics, Born and Wolf, Cambridge University Press, 60^{th} Anniversary Edition, 2019.
5. Atomic and Molecular Spectra: Laser, Raj Kumar, Knrn,2020 edition,2012.

Reference Books:

1. Optics, K D Moller, Oxford University Press, First edition,2007.
2. Fundamental of Optics, Jenkins and White, McGraw-Hill, Fourth Edition,2017.
3. Lasers and Non-linear Optics, B B Laud, New Age International Private Limited, 2011
4. Optics, Smith and Thomson, John Wiley and Sons, First edition,1971.

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Semester III (Practical)

PHCC302: Waves and Oscillations Laboratory (Credit: 1)

Course Objectives:

This course aims to introduce the practical's related to Waves and Oscillations

Course Outcomes (CO):

- Determine the expected value of time period for SHM.
- Determine the value of g using bar pendulum
- Determine the effect of area of the damper on damped oscillations
- Calculate the damping coefficient and Q factor for different dampers.
- Study the applications of CRO

List of Experiments:

Sl. No.	Title of the experiments
1	*Estimate limits on angular displacement for SHM by measuring the time period at different angular displacements and compare it with the expected value of time period for SHM.*
2	*Testing of active and passive components using CRO.*
3	*Determine the value of g using Kater's pendulum.*
4	*Study the effect of area of the damper on damped oscillations.*
5	*Plot amplitude as a function of time and determine the damping coefficient and Q factor for different dampers*
6	*Understand the applications of CRO by measuring voltage and time period of a periodic waveform using CRO.*
7	*Study the superposition of two perpendicular simple harmonic oscillations using CRO (Lissajous figures).*

Learning Resources:

Text Books:

1. Engineering Practical Physics, S. Panigrahi and B. Mallick, CENGAGE Learning, 2015.
2. B.Sc. Practical Physics, C.L. Arora, S Chand and Company Limited, 12th Edition,2010
3. Physics in laboratory, Electricity & Magnetism, Wave & Optics, Supriya Das and Mili Das, Santra Publication Pvt Ltd, 1st edition, 2020

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Semester III (Practical)

PHCC304: Optics Laboratory I (Credits:1)

Course Objectives:

This course aims to introduce the practical related to Optics.

Course Outcomes (CO):

In the successful completion of this laboratory course,

- Students will gain hands-on experience in using various optical instruments
- Making finer measurements of the wavelength of light using Newton Rings experiment, Fresnel Biprism, etc.
- Resolving power of optical equipment can be learnt firsthand.
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List of Experiments:

Sl. No.	Title of the experiments
1	*Determination of minimum angle of deviation of a prism.*
2	*Familiarization with Schuster's focusing and determination of the angle of prism.*
3	*To determine the refractive index of the material of a prism using sodium light.*
4	*To determine the dispersive power of a prism using mercury light*
5	*Diffraction grating using LASER*
6	*To determine wavelength of sodium light using Fresnel Biprism.*
7	*To determine wavelength of sodium light using newton's rings.*
8	*To determine dispersive power and resolving power of a plane diffraction grating.*
9	*To determine the wavelength of sodium source using Michelson's interferometer.*

Learning Resources:

Text Books:

1. Advanced Practical Physics for students, B.L.Flint and H.T.Worsnop, Asia Publishing House,1971.
2. A Text Book of Practical Physics, I.Prakash & Ramakrishna, ,Kitab Mahal, 11th Edition, 2011.
3. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, Heinemann Educational Publishers, 4th Edition, reprinted 1985.
4. A Laboratory Manual of Physics for undergraduate classes, D.P. Khandelwal, Vani Pub, 1985.
5. Practical Physics, G.L. Squires, Cambridge University Press, 4th Edition, 2015.

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Semester IV (Core Course)

PHCC401: Mathematical Physics I (Credits:04)

Course Objectives:

This course aims to introduce the Physics of Mathematical Physics I to the students.
Objectives are.

- To Study the basic concepts of Calculus.
- To Study the basic concepts of First and Second-Order differential equations.
- To Study the basic concepts of Vector Analysis.
- To study the basic concepts of Vector Integration.

Course Outcomes (CO):

After completion of the course, students will be able to:

CO1: Draw and interpret graphs of various functions.

CO2: Solve first and second-order differential equations and apply these to physics problems.

CO3: Explain the concept of gradient of scalar field and divergence and curl of vector fields.

CO4: Perform line, surface and volume integration.

CO5: To develop an understanding of apply Green's, Stokes' and Gauss's Theorems to compute these integrals.

Course Code: PHCC401	***Mathematical Physics I***	***L-T-P:C 3-1-0: 4***
Module I	**Calculus:** Recapitulate the concept of functions. Plot and interpret graphs of functions using the concepts of calculus. First Order Differential Equations: First order differential Equations: Variable separable, homogeneous, non-homogeneous, exact and inexact differential equations and Integrating Factors. Application to physics problems.	*12 hours*
Module II	**Second Order Differential Equations:** Homogeneous Equations with constant coefficients. Wronskian and general solution. Particular Integral with operator method, method of undetermined coefficients and method of variation of parameters. Cauchy-Euler differential equation and simultaneous differential equations of First and Second order.	*14 hours*
Module III	**Vector Analysis Vector Algebra:** Scalars and vectors, laws of vector algebra, scalar and vector product, triple scalar product, interpretation in terms of area and volume, triple cross product, product of four vectors. Scalar and vector fields. Vector Differentiation: Ordinary derivative of a vector, the vector differential operator. Directional derivatives and normal derivative. Gradient of a scalar field and its geometrical interpretation. Divergence and curl of a vector field. Laplacian operator. Vector identities.	*15 Hours*

Module IV	**Vector Integration:** Ordinary Integrals of Vectors. Double and Triple integrals, Jacobian. Notion of infinitesimal line, surface and volume elements. Line, surface and volume integrals of Scalar and Vector fields. Flux of a vector field. Gauss' divergence theorem, Green's and Stokes Theorems, their verification (no rigorous proofs) and applications.	*15 hours*

Learning Resources:

Text Books:

1. Advanced Engineering Mathematics, Erwin Kreyszig, J. Wiley and Sons, 10^{th} Edition 2023.
2. An introduction to ordinary differential equations, E. A. Coddington, Dover Publications Inc, 1989.
3. Vector Analysis: Schaum Outline Series, M. R Spiegel, McGraw Hill Education, 2^{nd} Edition, 2009.
4. Advanced Engineering Mathematics, D. G. Zill and W. S. Wright, Jones and Bartlett Learning, 5^{th} Edition, 2012.
5. Mathematical Physics, A.K. Ghatak, IC Goyal and S.J. Chua, Laxmi Publications Private Limited, 1^{st} Edition, 2016.

Reference Books:

1. Essential Mathematical Methods, K. F. Riley & M. P. Hobson, Cambridge Univ. Press, 1^{st} Edition, 2011.
2. Differential Equations with Applications and Historical Notes, George F. Simmons, McGraw Hill, 2^{nd} Edition, 2017.
3. Introduction to Vector Analysis, H.F. Davis and A. D. Snider, Wm. C. Brown Publishers; 6^{th} edition 1991.

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PHCC403: Analog Electronics (Credits:04)

Course Objectives:

This course aims to introduce the *Analog Electronics* to the students.

Objectives are.

- To Study the basic concepts of semiconductor devices and their applications.
- To study the basic concepts of Rectifier diodes, Zener diode, photodiode etc
- To emphasizes on understanding of amplifiers
- To Study the basic concepts of oscillators, operational amplifier and their applications.

Course Outcomes (CO):

After completion of the course, students will be able to:

CO1: Characterize and working of pn junction

CO2: Two terminal devices: Rectifier diodes, Zener diode, photodiode etc

CO3: NPN and PNP transistors: Characteristics of different configurations, biasing, stabilization and their applications.

CO4: CE and two stage RC coupled transistor amplifier using h-parameter model of the transistor.

CO5: Ideal and practical op-amps: Characteristics and applications.

Course Code: PHCC403	***Analog Electronics***	***L-T-P:C 3-1-0: 4***
Module I	**Semiconductor Diodes:** P and N type semiconductors. Energy Level Diagram. Conductivity and Mobility, Concept of Drift velocity.PN Junction Fabrication (Simple Idea). Barrier Formation in PN Junction Diode. Derivation for Barrier Potential, Barrier Width and Current for abrupt Junction. Equation of continuity, Current Flow Mechanism in Forward and Reverse Biased Diode.	*10 hours*
Module 11	**Two-terminal Devices and their Applications:** (1) Rectifier Diode: Half-wave Rectifiers. Centre-tapped and Bridge Full-wave Rectifiers, Calculation of Ripple Factor and Rectification Efficiency, C-filter, (2) Zener Diode and Voltage Regulation. Principle, structure and characteristics of (1) LED, (2) Photodiode and (3) Solar Cell, Qualitative idea of Schottky diode and Tunnel diode.	*10 hours*
Module II1	**Bipolar Junction transistors:** n-p-n and p-n-p Transistors. I-V characteristics of CB and CE Configurations. Active, Cutoff and Saturation Regions. Current gains α and β. Relations between α and β. Load Line analysis of Transistors. DC Load line and Q-point. Physical Mechanism of Current Flow	*11 hours*
Module IV	**Amplifiers:** Transistor Biasing and Stabilization Circuits. Fixed Bias and Voltage Divider Bias. Transistor as 2-port Network. h-parameter Equivalent Circuit. Analysis of a single-stage CE amplifier using Hybrid Model. Input and Output Impedance. Current, Voltage and Power Gains. Classification of Class A, B & C Amplifiers**.** Coupled Amplifier: Two stage RC-coupled amplifier and its frequency response.	*12 hours*

Module V	**Feedback in Amplifiers:** Positive and Negative Feedback. Effect of negative feedback on Input Impedance, Output Impedance, Gain, Stability, Distortion and Noise. Sinusoidal Oscillators: Barkhuizen's Criterion for self-sustained oscillations. RC Phase shift oscillator, determination of Frequency. Hartley & Colpitts oscillators.	*13 hours*

Learning Resources:

Text Books:

1. Integrated Electronics, J. Millman and C.C. Halkias, Tata Mc-Graw Hill, 2017.
2. Electronics: Fundamentals and Applications, J.D. Ryder, Prentice Hall, 5^{th} Edition, 1975.
3. Op-Amps and Linear Integrated Circuit, R. A. Gayakwad, Pearson, 4th edition, 1999.
4. Microelectronic circuits, A.S. Sedra, K.C. Smith, A.N. Chandorkar, Oxford University Press, 6^{th} Edition, 2014.
5. Semiconductor Devices: Physics and Technology, S.M. Sze, Wiley India, 2^{nd} Ed., 2002.
6. Electronic Principles, A. Malvino, D.J. Bates, Tata Mc-Graw Hill 52 Education, 7th Edition, 2018.
7. Electronic Devices & circuit Theory, R.L. Boylestad & L.D. Nashelsky, Pearson India, 10^{th} Edition, 2009.

Reference Books:

1. Solid State Electronic Devices, B. G. Streetman & S. K. Banerjee, PHI, 6^{th} Edition.,2009.
2. Learning Electronic Devices & circuits, S. Salivahanan & N. S. Kumar, Tata Mc-Graw Hill OP-Amps, 3^{rd} Edition, 2012.
3. Microelectronic Circuits, M.H. Rashid, Cengage Learning, 2^{nd} Edition, 2012.

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PHCC405: *Classical Physics I (Credits:04)*

Course Objectives:

The primary objective is to teach the students Classical Mechanics at a level more advanced than what they have learnt in B.Sc. This is a course which forms the basis of Physics of many areas of Physics.

Course Outcomes (CO):

After completion of the course, students will be able to:

CO1: Explain the concept of Lagrangian Formulation of Mechanics

CO2: Apply the concept of Lagrange's equations; gyroscopic forces; dissipative systems; Jacobi integral; gauge invariance etc.

CO3: Describe the concept of Central force; definition and characteristics etc.

CO4: Describe the concept of Canonical transformation, Poisson bracket etc.

CO5: Explain the concept of Rigid body motion, Central force problems (the Kepler problem and scattering).

Course Code: PHCC405	***Classical Physics I***	***L-T-P:C 3-1-0: 4***
Module I	Lagrangian Formulation of Mechanics: The variational principles and least action principles, Lagrangian equations of motion, constraints, Principle of virtual work and D'Alembert's principle, generalized coordinates, conjugate variables and phase space, symmetries and conservation laws.	*10 Hours*
Module 11	Lagrange's equations; gyroscopic forces; dissipative systems; Jacobi integral; gauge invariance; generalized coordinates and momenta; integrals of motion; symmetries of space and time with conservation laws; invariance under Galilean transformations. Rotating frames; inertial forces; terrestrial and astronomical applications of Coriolis force.	*15 Hours*
Module II1	Central force; definition and characteristics; Two-body problem; closure and stability of circular orbits; general analysis of orbits; Kepler's laws and equation; artificial satellites; Rutherford scattering. Principle of least action; derivation of equations of motion; variation and end points; Hamilton's principle and characteristic functions; Hamilton-Jacobi equation.	*15 Hours*
Module IV	Canonical transformation; generating functions; Properties; group property; examples; infinitesimal generators; Poisson bracket; Poisson theorems; angular momentum PBs; small oscillations; normal modes and coordinates.	*10 Hours*
Module V	Rigid body motion (inertia tensors, Euler angles, rotation matrices) Central force problems (the Kepler problem and scattering)	*6 Hours*

Learning Resources:

Text Books:

1. Classical Mechanics, Goldstein, H., Pearson Education, 3rd edition, 2011.

2. Mechanics: Vol I (Course of Theoretical Physics S) Landau, L.D., Lifshitz, E.M., Butterworth-Heinemann, 3rd edition, 1982
3. Classical Mechanics, N C Rana, P S Joag, Tata McGraw-Hill, 2017.
4. Mechanics, A Sommerfeld, Academic Press, 1952.
5. Introduction to Dynamics, I Perceival, D Richards, Cambridge Univ. Press. 1982

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Semester IV (Practical)

PHCC402: General Physics Lab II (Credits:02)

Course Objectives:

This course aims to introduce the practical's related to thermal Physics and Electricity and Magnetism.

Course Outcomes (CO):

The practical knowledge of Thermodynamics, Electricity, and magnetism doing experiments: Engine, electric vibrations. They would also learn electric phenomena such as diode, and CRO and do experiments related to electric devices.

Complete any Eight practicals from the given experiments:

Sl. No.	Title of the experiments
1	*Study of Linear Expansion Coefficient.*
2	*Study of Transverse Standing Waves on a String.*
3	*Study of simple harmonic motion.*
4	*Study of Longitudinal Standing Waves in a Sound Tube.*
5	*Study of Archimedes principle and density.*
6	*Uses of Newton's ring apparatus for obtaining interference fringes.*
7	*Study of series and parallel circuits using capacitor (voltage-current division rule)*
8	*Determination of frequency of AC by using a sonometer.*
9	*Study of digital multimeter for measuring (i) resistances, (ii) ac and dc voltages, (iii) DC Current, and (iv) checking electrical fuses.*
10	*Validation of Biot-Savart law*

Learning Resources:

Text Books:

1. Advanced Practical Physics for students, H.T. Flint, B. L.Worsnop, Khosla Publishing House, 1971.
2. Advanced level Physics Practical, Michael Nelson, Jon M. Ogborn, Heinemann Educational Publishers, 4th Edition, reprinted 1985.
3. A Text Book of Practical Physics, I. Prakash, Ramakrishna, Kitab Mahal, 11th Edition, , 2011.
4. A Laboratory Manual of Physics for undergraduate classes, D. P. Khandelwal, Vani Publication, 1985,

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Second Year (Exit Course)

PHEX201: LED light Repairing and Maintenance (Credits:02)

Course Objectives:

This is a course objectives are.

- To use the knowledge of basics of electronics and LED to carry out work.
- Perform LED repair and assembly as per the recommended quality standards.
- Implement the soft skills that are required to carry out work efficiently.

Course Outcomes (CO):

After completion of the course, students will be able to:

CO1: Explain basics of LED and semiconductor.

CO2: Apply the knowledge for the repair of LEDs.

CO3: Identify the importance of reduction electronic waste management and Intellectual Property Rights (IPR).

Course Content:

(Any 12 experiments + 3 Experimental Activities)

1. To identify the different LEDs in the circuit and measure its activities (ON/OFF).
2. To measure the Power and Energy of different LEDs.
3. To study how soldering and de-soldering of LED in done. (Hands on Training)
4. To check the voltage and current output at different sections of units of LED.
5. To check LEDs in series and parallel circuit. (Hands on Training)
6. To check the burnt out and damage LEDs in bulbs.
7. To perform repair and replacement of LEDs and other components.
8. To study an assembly of LED bulbs / Strips dismantle with different wattage.
9. To identify the operation of LED in the fiber optics.
10. To check and replace the burnt and damage LED strips
11. To demonstrate the process of soldering if loose, de-soldered wires and connections are found.
12. To demonstrate basic knowledge of assembly of products such as spot light, LED bulb and LED tube light. 13. To study the characteristics of three indicator LEDs that emit in the infrared, red and blue parts of the spectrum.
14. To investigate the relationship between the Threshold Voltage of an LED and the wavelength of light emitted from the LED.
15. To study and measure the P-I characteristics of light-emitting diode (LED) used in optical fiber communication as a light source.
16. To measure LED light output using a Photodiode.
17. To study the wavelength characteristics of LED for different 3 colors and measure it.
18. To study the properties of LED and how they can combine in the 7-segment display.

Additional Activities to be conducted related to subject (Any-3)

1. *Mini Projects with report.*
2. *Industrial /Research organization /Working organization /Field visit with report.*
3. *Any one computer-aided demonstrations.*
4. *Démonstrations – Any one demonstrations.*

Note: *Students have to perform 12 experiments and participate in additional three activities equivalent to 3 experiments with 12 experiments. Total laboratory work with additional activities should be 15 experiments.*

Learning Resources:

Text Books:

1. NSDC Skill Based Participant Handbook LED Light Repair Technician (E), Publisher Rachna Sagar Pvt. Ltd.
2. Vigyan Ashram, Design Manual (LED).

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PHEX203: *Maintenance and Repairing of Physics Lab Equipment (Credits:02)*

Course Objectives:

This is a course objective are.

- To use the knowledge of basics laboratory equipment's to carryout work
- Knowledge to create awareness of Lab Equipment
- Perform equipment repair and assembly as per the recommended quality standards 4. Implement the soft skills that are required to carry out work efficiently.
- To expose the students to the repairing of equipment.

Course Outcomes (CO):

After completion of the course, students will be able to:

CO1: Identify Lab Equipment and Electronic Components.

CO2: Interpret the basic principles of physical instruments.

CO3: Apply the knowledge for the repair.

CO4: Identify the importance of reducing electronic waste management.

Course Content:

(Any 12 experiments + 3 Experimental Activities)

1) To identify the different equipment in used in the physics lab.
2) To study least count and measure the diameter of different sizes of thin wire using a screw gauge.
3) To study least count and measure the diameter of different size of rod using vernier calliper.
4) To study least count and how to measure the Current and Voltage using ammeter and voltmeter.
5) To study the DC and AC Voltage, Current, and Power using a multimeter.
6) To study the function/operation of resistance and measure the values of different resistance using color code and multimeter.
7) To study the function/operation of capacitor and measure the values of different capacitor using multimeter.
8) To measure current and voltage when resistance connected in series and parallel form.
9) To measure current and voltage when capacitor connected in series and parallel form.
10) To check and identify the fault in the circuit and how to repair it.
11) To study of CRO for the measurement of voltage and frequency.
12) To study the calibration of Spectrometer.
13) To study the function and operation of simple p-n junction and Zener diode.
14) To study the function and operation of IC. (IC 555, IC 741, IC 7400, etc.)
15) To study the simple pendulum to measure "g".
16) To study the telescope and measure the oscillation of the pendulum.
17) To study PCB and Breadboard for connections of simple electric components.
18) To study and measure of wavelength of LASER light.
19) To study and demonstration of various geometrical glasses.
20) To study the use of a stopwatch.
21) To study how to draw graphs using Excel.

22) To study the principle and operation of the Transformer.
23) To study an operation and how an electric fan is repaired.
24) To study an operation and how the power supply is repaired.
25) To study how spectrums are obtained using normal prism.
26) To study and repair mobile chargers.
27) To study function generator.

Additional Activities to be conducted related to subject (Any-3)

1. Mini Projects with report.
2. Industrial /Research organization /Working organization /Field visit with report.
3. Any one computer-aided demonstrations.
4. Démonstrations – Any one demonstrations.

Note: *Students have to perform 12 experiments and participate in additional three activities equivalent to 3 experiments with 12 experiments. Total laboratory work with additional activities should be 15 experiments.*

Learning Resources:

Text Books:

1. NSDC Skill Based Participant Handbook LED Light Repair Technician (E), Publisher Rachna Sagar Pvt Ltd.

*Students exiting the program after securing **80 credits** will be awarded a **UG Diploma** in the relevant **Discipline/Subjec**t provided they secure an additional **4 credits** in skill-based vocational courses offered during the first year or second-year summer term.*

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Semester V (Core Course)

PHCC501: Mathematical Physics II (Credits:04)

Course Objectives:

This course aims to equip students with advanced techniques in the Mathematical Physics.
Objectives are.

- To Study the basic concepts of Vector Calculus.
- To Study the basic concepts of Matrices.
- To Study the basic concepts of Differential equations.
- To study the basic concepts of Special functions.
- To Study the basic concepts of Fourier analysis.

Course Outcomes (CO):

After completion of the course, students will be able to:

CO1: Apply vector calculus in curvilinear coordinates for solving physical problems.

CO2: Work with matrices and tensors, including diagonalization and eigenvalue problems.

CO3: Solve first and second-order differential equations using methods such as Frobenius.

CO4: Utilize special functions like Bessel and Legendre in physics contexts.

CO5: Perform Fourier and Laplace transformations to analyze physical systems.

Course Code: PHCC501	***Mathematical Physics II***	***L-T-P:C 3-1-0: 4***
Module I	**Vectors and Curvilinear Coordinates:** Gradient, divergence, and curl in curvilinear systems, Laplacian in Cartesian, spherical, and cylindrical coordinates, Orthogonal curvilinear coordinates and metric tensors.	*12 hours*
Module II	**Matrices and Tensors:** Hermitian, orthogonal, and unitary matrices, Eigenvalue problems, Cayley-Hamilton theorem, Cartesian, covariant, and contravariant tensors, quotient law.	*12 hours*
Module III	**Differential Equations:** First and second-order equations with constant coefficients, Series solutions and Frobenius method, Bessel equations, Wronskian, and linear independence	*11 hours*
Module IV	**Special Functions:** Bessel, Legendre, Hermite, and Laguerre functions, Generating functions, orthonormality, Beta and Gamma functions	*11 hours*
Module V	**Fourier Analysis and Integral Transformations:** Fourier theorem, series, and integrals, Laplace transform and applications in physical systems	*10 hours*

Learning Resources:

Textbooks:

1. Mathematical Methods for Physicists, George B. Arfken, Hans J. Weber and Frank E. Harris, Elsevier, Seventh edition, 2012
2. Mathematical Physics, A.K. Ghatak, L.C. Goyal, and S.J. Chua, Laxmi Publications Private Limited, First Edition, 2016
3. Mathematical Physics – P.K. Chattopadhyay, New Age International Private Limited, Third edition, 2022
4. Advanced Engineering Mathematics, Erwin Kreyszig, John Wiley & Sons Inc, 10th edition, 2010
5. Theory and Problems of Vector Analysis (Schaum's Outline Series), M.R. Spiegel, McGraw-Hill Education / Asia, SI metric ed edition, 1980

Reference Books:

1. Applied Mathematics for Engineers and Physicists, L.A. Pipes and L.R. Harvill, Dover Pubns, 3rd edition, 2014
2. Mathematical Physics – H.K. Dass and Dr. Rama Verma, S Chand Publishing, Eighth edition, 2019

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PHCC503: *Solid State Physics I (Credits:04)*

Course Objectives:

This course aims to develop a deep understanding of the following properties of solids:

- Structural
- Electronic
- Magnetic
- Crystallography
- Bonding
- Free electron theory
- Lattice dynamics
- Superconductivity

Course Outcomes (CO):

After completion of the course, students will be able to:

CO1: Analyze the structure and symmetry of crystalline solids.

CO2: Explain bonding mechanisms in solids and calculate cohesive energy.

CO3: Apply free electron theory to explain electrical and thermal properties of metals.

CO4: Explain the concept of lattice vibrations and their contribution to specific heat.

CO5: Explore magnetic properties of materials and the phenomenon of superconductivity.

Course Code: PHCC503	***Solid State Physics I***	***L-T-P:C 3-1-0: 4***
Module I	**Structure and Symmetry:** Crystalline vs amorphous solids, Miller indices, Bragg's law, Reciprocal lattice, Brillouin zones, NaCl, CsCl structures	*12 hours*
Module II	**Bonding in Solids:** Ionic, covalent, metallic, Van der Waals bonding, Lennard-Jones potential, and Madelung constant	*6 hours*
Module III	**Free Electron Theory of Metals:** Fermi-Dirac distribution, Density of states, Wiedemann-Franz law, Bloch theorem, and Kronig-Penney model.	*10 hours*
Module IV	**Lattice Vibrations:** Einstein and Debye models, phonons, Dispersion relations in solids, acoustic and optical modes.	*12 hours*
Module V	**Magnetic Properties and Superconductivity:** Diamagnetism, Para magnetism, ferromagnetism, hysteresis, Quantum mechanical treatment, Type I and Type II superconductors, and Meissner effect.	*16 hours*

Learning Resources:

Textbooks:

1. Crystallography for Solid State Physics, A.R. Verma and O.N. Srivastava, New Age International Private Limited, Second edition, 1991

2. Introduction to Solids, Leonid V. Azaroff, McGraw Hill Education, New edition, 2017
3. Solid State Physics, C. Kittel, Wiley, Eighth edition, 2012
4. Solid State Physics, Ashcroft and Mermin, Brooks/Cole, New edition, 2021
5. Solid State Physics, A. J. Decker, Laxmi Publications, 2008

Reference Books:

1. Solid State Physics: An Introduction to Principles of Materials Science, H. Ibach and H. Luth, Springer-Verlag Berlin and Heidelberg GmbH & Co. K, 2nd edition, 1995
2. Principles of the Theory of Solids, J.M. Ziman, Cambridge University Press; 2nd edition, 1979

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PHCC505: *Electrodynamics I (Credits:04)*

Course Objectives:

This course provides an in-depth understanding of the following:

- Electrostatics
- Current electricity
- Magnetism
- Alternating current
- Electromagnetic wave propagation

  It also covers applications of Maxwell's equations.

Course Outcomes (CO):

After completion of the course, students will be able to:

CO1: Apply Gauss's law to various charge distributions and solve Poisson's and Laplace's equations.

CO2: Define thermoelectric effects and use DC bridges for electrical measurements.

CO3: Analyze magnetic fields and their interactions with current-carrying conductors.

CO4: Analyze alternating current circuits and compute power, inductance, and mutual inductance.

CO5: Apply Maxwell's equations to describe electromagnetic wave propagation and understand waveguide properties.

Course Code: PHCC503	***Electrodynamics I***	***L-T-P:C 3-1-0: 4***
Module I	**Electrostatics (10 hours):** Gauss's law, applications, electric potential and field, Poisson's & Laplace's equation, Boundary conditions, capacitors, dielectric polarization, and Clausius-Mosotti equation.	*10 hours*
Module II	**Current Electricity:** Galvanometers, DC bridges, Kelvin's double bridge, Thermoelectric effects, LR, CR, and LCR circuits	*10 hours*
Module III	**Magnetism:** Biot-Savart's law, Ampere's circuital law, Gauss's theorem in magnetism, Magnetic materials: diamagnetism, paramagnetism, ferromagnetism.	*10 hours*
Module IV	**Alternating Current:** RMS values of AC current, LCR circuits in AC, Self-inductance, mutual inductance, power in AC circuits.	*10 hours*
Module V	**Electromagnetism and Wave Propagation:** Maxwell's equations, Poynting theorem, energy and momentum conservation, EM wave propagation, laws of reflection, transmission, waveguides.	*16 hours*

Learning Resources:

Textbooks:

1. Introduction to Electrodynamics, David J. Griffiths, Pearson Education India Learning Private Limited, 4th edition, 2015
2. Electricity and Magnetism, Edward M. Purcell and David J. Morin, Cambridge University Press, 3rd edition,2013
3. Electromagnetism - Vol. 1: Theory, Ashutosh Pramanik, Prentice Hall India Learning Private Limited, 2014
4. Classical Electrodynamics, J.D. Jackson, Wiley, 2020
5. Fundamentals Of Magnetism & Electricity, D.N. Vasudeva, S Chand & Company, 2011

Reference Books:

1. EM Waves and Fields, P. Lorrain and O. Corson, W. H. Freeman & Co Ltd, 3rd edition, 1987
2. Electricity and Magnetism, A. S. Mahajan and A.A. Rangwala, McGraw Hill Education, 2017

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PHMC501: *Radiation Physics (Credits:03)*

Course Objectives:

This course provides an in-depth understanding of the following:

- Interaction of radiation with matter
- Radiation detectors
- Measurement of radiation exposure and dose
- Internal and external dosimetry

Course Outcomes (CO):

After completion of the course, students will be able to:

CO1: Explain the interaction of radiation with matters.

CO2: Apply the detectors to find the radiation.

CO3: Analyze how to measure the radiation exposure and dose.

CO4: Analyze the internal and external dosimetry.

Course Code: PHMC501	***Radiation Physics***	***L-T-P:C 3-0-0: 3***
Module I	**Interaction of radiation with matter**: Passage of heavy charged particles through matter: Energy loss by collision, maximum energy loss in a single collision, range energy relation, Bragg curve, Specific ionization, mean excitation energies, Bethe-Bloch formula collision stopping power, radiation stopping power. Interaction of neutrons: Neutron sources, General properties, energy classification, elastic and inelastic scattering, nuclear reaction, neutron activation and induced activity, radioisotope production, nuclear fission.	*13 hours*
Module II	**Radiation detectors:** Characteristics of organic and inorganic scintillation counters, Resolving time, Semiconductor devices - physics of semiconductors, diffused junction, surface barrier and ion-implanted detectors, Examples, Semiconductor spectrometer, Analysis of pulse height of spectra, superheated drop detectors. Neutron detectors: BF3 counters, fission chambers, activation methods, Neutron time of flight method. Preamplifier circuits, noise, linear pulse amplifier, pulse shaping, pulse stretching, operation amplifier, Pulse discriminators, coincidence and anti-coincidence circuits. Scalers, single and multichannel analyzer, charge sensitive amplifier. Principles of measurement (collimation shielding, geometry, calibration), Radiation survey instruments.	*11 hours*
Module III	**Measurement of radiation exposure and dose**: Particle flux and fluence, energy flux and fluence, cross section, linear and mass absorption coefficient, stopping power and LET. Exposures and its measurement, absorbed dose and its relation to exposure. Electronic equilibrium, Bragg-Gray principle and air wall chamber, Kerma, Kerma rate constant. Biological effectiveness, Equivalent dose, effective dose, Committed equivalent dose, Ambient and directional equivalent dose. Tissue equivalence.	*11 hours*

Module IV	**Internal and external dosimetry:** Biological half-life, effective half-life, selectivity of organs, beta particle dosimetry. Calculation of integral dose due to internal deposition, specific effective energy, annual limit on intake, derived air concentration. Dosimeters: Primary and secondary dosimeters. Pocket dosimeters, films, TLDs. Chemical and calorimetric devices.	*11 hours*

Learning Resources:

Textbooks:

1. Radiation Detection and Measurement, G. F. Knoll, John Wiley & Sons Inc, 4th edition, 2010
2. Nuclear Radiation Detectors, S. S. Kapoor and V. S. Ramamurthy, New Age International Private Limited, Second edition, 2022
3. Introduction to Health Physics, Herman Cember, Pergamon Pr, Revised, Enlarged, Subsequent edition, 1983
4. Radiation Dosimetry, Attix F H et al, Vol. I, II and III Academic Press, NY, 1968

Reference Books:

1. Source book on Atomic Energy, Glasstone S, Krieger Publishing Company, 3rd edition, 2012
2. Fundamentals of Radiation Dosimetry, Greening J R, Bristol, Adam Hilger, Medical Physics Hand Book 6, 1981
3. Health Physics, Morgan K Z and Turner J E, Wiley, NY, 1978
4. Thermoluminescence and TL Dosimetry, Horowitx Y S, Boca Raton (eds.), Vol. I, II and III, CRC Press, 1984
5. Radioactivity and its Measurements, Mann W B, Et al, Pergamon Oxford, 1980
6. Radionuclide Decay Scheme and Dose Estimation, Dillman L T, et al, Society of Nuclear Medicine, NY, MIRD Pamphlet No. 10, 1975
7. Radiation Protection Standards, Taylor L S, CRC Press, Cleveland, Ohio, 1971
8. Radiation Protection in Hospitals Medical Sciences Series, Richard F. Mould, Adam Hilger Ltd, Bristol and Boston, 1985
9. The Dosimetry of ionising radiation, Kenneth R Kase, Bjarngard B E and Attix F H, Vol I & II, Academic Press, 1985 & 1987
10. Radiation Protection, Ronald L. Kathren, Adam Hilger Ltd. International Publishers Services, 1985
11. Environmental Radioactivity, Merril Eisenbud, Academic Press, Orlando, Third Edition 1987
12. Atoms, Radiation & Radiation Protection, James E Turner, WILEY.VCH, Third completely revised and enlarged edition, 2023

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Semester VI (Core Course)

PHCC601: Atomic and Molecular Physics I (Credits:04)

Course Objectives:

This course aims to explore advanced concepts in atomic and molecular physics, including:

- Atomic models
- Electron spin and quantum numbers
- Atomic and molecular spectra
- Laser physics

Course Outcomes (CO):

After completion of the course, students will be able to:

CO1: Explain and analyze the development of atomic models, including Bohr and Sommerfeld models, and the experimental foundations of electron spin.

CO2: Describe the behavior of single and multi-electron atoms, including spin-orbit coupling, spectral line intensities, and effects like Zeeman and Paschen-Back.

CO3: Analyze molecular spectra by understanding rotational, vibrational, and electronic transitions and molecular energy levels.

CO4: Explain the principles of laser operation, including population inversion, rate equations, and the characteristics of laser light.

CO5: Understand quantum numbers and atomic orbitals, including the Pauli exclusion principle and the significance of various quantum numbers in atomic structure.

Course Code: PHCC601	*Atomic and Molecular Physics I*	*L-T-P:C 3-1-0: 4*
Module I	**Atomic Models and Fundamental Concepts:** Bohr and Sommerfeld models, Impact of finite nuclear mass on Rydberg constant, Electron spin, Franck-Hertz, and Stern-Gerlach experiments	*12 hours*
Module II	**Single and Multi-Valence Electron Atoms:** Magnetic dipole moment, spin-orbit coupling, Vector atom model, LS and JJ coupling, Spectral line intensity, Zeeman and Paschen-Back effects.	*12 hours*
Module III	**Molecular Spectra:** Rotational, vibrational, and electronic spectra, Overview of molecular energy levels and transitions.	*10 hours*
Module IV	**Laser Physics:** Einstein coefficients, stimulated emission, Population inversion, rate equations, properties of laser light, Types of lasers: Ruby, He-Ne, Nd lasers.	*14 hours*
Module V	**Quantum Numbers and Atomic Orbitals:** Quantum numbers: Principal, angular, magnetic, and spin, atomic orbitals and the Pauli exclusion principle.	*8 hours*

Learning Resources:

Textbooks:

1. Quantum Physics of Atoms, Molecules, Solids, Nuclei, and Particles, Robert Eisberg, Robert Resnick, Wiley, Second edition, 2006
2. Introduction to Atomic Spectra, H.E. White, MCGRAWHILL EXCLUSIVE (CBS), 2019
3. Principles of Lasers, Orazio Svelto, Springer-Verlag New York Inc., 5th ed. 2010 edition, 2009
4. Optics, P.K. Srivastava, CBS PUBLISHERS AND DISTRIBUTORS PVT LTD, First Edition, 2011
5. Atom, Laser & Spectroscopy, S.N. Thakur and D.K. Rai, Prentice Hall India Learning Private Limited, 2nd edition, 2013

Reference Books:

1. Introduction to Molecular Spectroscopy, G.M. Barrow, McGraw-Hill Inc. US, 1962
2. Atoms, Molecules, and Photons, Wolfgang Demtröder, Springer, 3rd ed. 2018 edition, 2019

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PHCC603: *Nuclear Physics (Credits:04)*

Course Objectives:

This course introduces key concepts in nuclear physics, including:

- Nuclear forces and stability
- Nuclear models and reactions
- Accelerators and detectors
- Particle physics and cosmic rays

Course Outcomes (CO):

After completion of the course, students will be able to:

CO1: Explain the nature of nuclear forces, nuclear stability, and radioactive decay processes like alpha, beta, and gamma decay.

CO2: Analyze nuclear models such as the liquid drop model and the shell model and apply the Bethe-Weizsäcker mass formula to problems in nuclear stability and decay.

CO3: Evaluate nuclear reactions including fission and fusion processes and understand their applications in thermonuclear reactions and nuclear reactors.

CO4: Explain the principles and workings of particle accelerators such as Van de Graaff, Cyclotron, and Synchrotron, as well as detectors like Geiger-Mueller counters.

CO5: Outline the basics of particle physics, including leptons, baryons, mesons, quarks, and cosmic ray phenomena.

Course Code: PHCC603	***Nuclear Physics***	***L-T-P:C 3-1-0: 4***
Module I	**Nuclear Forces and Stability of Nuclei:** Nucleon-nucleon forces, nuclear stability, Alpha, beta, gamma decay, and selection rules.	*13 hours*
Module II	**Nuclear Models:** Liquid drop, shell models, Bethe-Weizsäcker mass formula, applications to fission and alpha decay.	*13 hours*
Module III	**Nuclear Reactions:** Fission and fusion processes, Thermonuclear reactions, nuclear reactors, and Q-value of reactions.	*10 hours*
Module IV	**Accelerators and Detectors:** Van de Graaff, Cyclotron, Synchrotron, linear accelerators, Geiger-Mueller counters, ionization chambers, and scintillation detectors.	*10 hours*
Module V	**Particle Physics and Cosmic Rays:** Leptons, baryons, mesons, conservation laws, Quarks, color charge, and cosmic ray composition.	*10 hours*

Learning Resources:

Textbooks:

1. Introductory Nuclear Physics, S.S.M. Wong, Prentice Hall India Learning Private Limited, 1996
2. Nuclear Physics, V. Devanathan, Alpha Science Intl Ltd, 2nd edition, 2011
3. Concepts of Nuclear Physics, B.L. Cohen, McGraw Hill Higher Education, 1st edition, 1974
4. Fundamentals of Nuclear Physics, B.B. Srivastava, Rastogi Publications, 1st edition, 2018
5. Introduction to Elementary Particles, D.J. Griffiths, Wiley-VCH, 2nd edition, 2008

Reference Books:

1. Introduction to Nuclear Physics, H.A. Enge, Addison Wesley Publishing Company, 1966
2. Introduction to High Energy Physics, D.H. Perkins, Cambridge University Press, 4th edition, 2000

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PHCC605: *Digital Electronics (Credits:04)*

Course Objectives:

This course introduces foundational concepts in digital electronics, focusing on:

- Number systems and codes
- Logic gates and Boolean algebra
- Combinational and sequential logic circuits
- Programmable logic devices

Course Outcomes (CO):

After completion of the course, students will be able to:

CO1: Explain various number systems, perform conversions between bases, and carry out arithmetic operations in binary, octal, and hexadecimal systems.

CO2: Simplify Boolean expressions using Boolean algebra, and design digital circuits using logic gates.

CO3: Compare different digital logic families (TTL and CMOS) based on their characteristics such as noise margin, fan-in, and fan-out.

CO4: Design and analyze combinational logic circuits using methods like Karnaugh maps, and implement logic functions using multiplexers, encoders, and decoders.

CO5: Design sequential logic circuits using flip-flops, counters, and shift registers, and understand the basics of programmable logic devices such as ROM, PLA, PAL, and FPGA.

Course Code: PHCC605	***Digital Electronics***	***L-T-P:C 3-1-0: 4***
Module I	**Number Systems and Codes:** Decimal, Binary, Hexadecimal, and Octal number systems, Base conversions, Binary, octal, and hexadecimal arithmetic (addition, subtraction by complement method, multiplication), Representation of signed and unsigned numbers, Binary Coded Decimal (BCD) code.	*12 hours*
Module II	**Logic Gates and Boolean Algebra:** Introduction to Boolean Algebra and Boolean operators, Truth tables of OR, AND, NOT gates, XOR, XNOR, and universal gates (NOR, NAND), Simplification of Boolean expressions using Karnaugh maps, Standard representation of logic functions (SOP and POS).	*12 hours*
Module III	**Digital Logic Families:** Fan-in, fan-out, noise margin, power dissipation, Speed-power product, figure of merit, TTL and CMOS families and their comparison.	*8 hours*
Module IV	**Combinational Logic Analysis and Design:** Multiplexers, Demultiplexers, Encoders, Decoders, Binary Adder and Subtractor, Karnaugh map minimization techniques, Implementing logic functions with multiplexers.	*12 hours*
Module V	**Sequential Logic and Programmable Devices:** Flip-flops-SR, JK, T, D flip-flops, Clocked and edge-triggered flip-flops, Counters (synchronous, asynchronous, and modulo-N), Shift registers, ROM, PLA, PAL, CPLD, FPGA basics.	*12 hours*

Learning Resources:

Textbooks:

1. Digital Design, M. Morris Mano, Pearson Education, Sixth edition, 2018
2. Digital Fundamentals, Thomas L. Floyd, Pearson Education Limited, 11th edition, 2015
3. Digital Electronics: Theory and Practice, W.H. Gothmann, Prentice Hall India Learning Private Limited, 2nd edition, 1982
4. Digital Principles, R.L. Tokheim, McGraw Hill, 3rd edition, 1993
5. Verilog HDL Primer, J. Bhasker, Star Galaxy Pub, 3rd edition, 2005

Reference Books:

1. Digital Design and Synthesis with Verilog HDL, Samir Palnitkar, Pearson India, 2nd edition, 2003
2. Digital Principles and Applications, A.P. Malvino, McGraw Hill Education, Eighth edition, 2014

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Semester VI (Practical)

PHCC606: *Electronics Lab (Credits:02)*

Course Objectives:

This course aims to introduce the practical's related to Digital Electronics.

Course Outcomes (CO):

The practical knowledge of Digital Electronics.

Complete any Eight practicals from the given experiments:

Sl. No.	Title of the experiments
1	*To verify and design AND, OR, NOT, and XOR gates using NAND gates.*
2	*To convert a Boolean expression into logic gate circuit and assemble it using logic gate ICs.*
3	*Design a half and full adder.*
4	*Design a half and full subtractor.*
5	*Design a seven-segment display driver.*
6	*Design a 4 x 1 multiplexer using gates.*
7	*To build a flip- flop circuits using elementary gates. (RS, clocked RS, D-type).*
8	*Design a counter using d/t/jk flip-flop.*
9	*Design a shift register and study serial and parallel shifting of data.*
10	*To design and study of a Regulated Power Supply using diodes.*
11	*To draw the characteristics of a transistor in CE and CB configuration*
12	*To draw the characteristics of a Zener Diode and to study its use as a voltage regulator*

Learning Resources:

Text Books:

1. Digital Systems: Principles and Applications, Ronald J. Tocci, Neal S. Widmer, Gregory L. Moss, Pearson, 10th edition, 2006
2. Digital Design, M. Morris Mano and Michael D. Ciletti, Pearson Education, Sixth edition, 2018
3. Fundamentals of Digital Circuits, A. Anand Kumar, PHI, 4th edition, 2016
4. Digital Logic and Computer Design, M. Morris Mano, Masood Books UP, 2018

*Students exiting the program after securing **120 credits** will be awarded **UG Degree** in the relevant Discipline/**Subject**.*

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Semester VII (Core Course)

PHCC701: Mathematical and Computational Methods in Physics (Credits:04)

Course Objectives:

This course aims to learn to solve physics problems using mathematical and computational methods.

- To Study the basic concepts of Curvilinear coordinates.
- To Study the basic concepts of Linear spaces and operators
- To study the basic concepts of Algorithms and Flowcharts.
- To study the basic concepts of Scientific Programming

Course Outcomes (CO):

After completion of the course, students will be able to:

CO1: Explain the basic concept of coordinate systems, gradient, curl, divergence, etc.

CO2: Interpret the basics of vector spaces, operators, matrix representation, etc.

CO3: Illustrate the use of flowcharts, algorithms, etc.

CO4: Identify the basics of the application of scientific Programming to solve problems.

Course Code: PHCC701	*Mathematical and Computational Methods in Physics II*	***L-T-P:C 3-1-0: 4***
Module I	Numerical Analysis: Methods for determination of zeroes of linear and non-linear algebraic equations and transcendental equations, solutions of simultaneous linear equations, Iterative method, Matrix inversion.	*10 hours*
Module II	Linear fitting and interpolation: Interpolation with equally spaced and unevenly spaced points, curve fitting, polynomial, least square and cubic spline fitting. Linear spaces and operators.	*10 hours*
Module III	Numerical differentiation and integration: Newton-cotes formulae, Error estimates, Gauss 'method. Numerical solution of ordinary differential equation: Euler and Runge Kutta methods. Algorithms and Flowcharts:	*9 hours*
Module IV	Random variate: Monte-Carlo evaluation of integrals and error analysis, methods of importance sampling, Random Walk, rejection Method, Metropolis algorithm. Scientific Programming:	*9 hours*
Module V	Programming: Elements of Computer programming with C ++.	*18 hours*

Learning Resources:

Text Books:

1. Computational Physics: An Introduction, R. C. Verma, et al. New Age International Publishers, 1st edition 2005.
2. Mathematical Methods for Physics and Engineers, K.F Riley, M.P. Hobson and S. J. Bence, Cambridge University Press, 3rd edition, 2006.

3. Numerical Methods for Mathematics, Science and Engineering, J.H. Mathews, Pearson Education US, 2^{nd} edition 1993.
4. Computer programming in Fortran 90 and 95, V. Rajaraman, Prentice-Hall of India, 1997. A Textbook of Applied Electronics, R. S. Sedha, S.Chand & Co. 3^{rd} edition 2008
5. Mathematical Physics, Partha Goswami, Cengage Learning, 1st edition, 2012.

Reference Books:

1. Advanced Engineering Mathematics, D.G. Zill and W. S. Wright, Jones and Bartlett Learning, 5^{th} edition,2012.
2. Numerical Recipes: The Art of Scientific Computing, William H. Press, Saul A. Teukolsky, William T. Vetterling, Brian P. Flannery, Cambridge University Press, 3^{rd} edition 2007.

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PHCC703: *Quantum Mechanics I (Credits:04)*

Course Objectives: This course aims to provide insight into concepts that go beyond the realm of classical mechanics. The course comprises:

- Overview of physics beyond classical mechanics and formalism of quantum mechanics.
- Discuss the fundamental concept of quantum mechanics.
- Use of mathematical tools to solve quantum problems.
- Application of quantum concept in harmonic oscillator, electromagnetic field, etc.
- Gives an idea of the degeneracy of many particle systems, symmetric and unsymmetric wave functions.

Course Outcomes (CO): Outcome of this course enrich student to correlate with:

After completion of the course, students will be able to:

CO1: Understanding the fundamentals of quantum mechanics, properties, and their physical significance

CO2: To conceptualize the postulate of quantum mechanics, which involves the formalism of wave equations and their application in one-dimensional problems

CO3: Usage of mathematical operators to solve quantum problems.

CO4: Solve different problems related to the dynamics of subatomic particles.

CO5: Formulate new approximation methods for solving quantum mechanical problems.

Course Code: PHCC702	***Quantum Mechanics I***	***L-T-P:C 3-1-0: 4***
Module I	**Introduction And Overview of Quantum Mechanics:** Brief introduction to origins of quantum Physics, Wave packets, Dirac notation, Operators and their eigenvalues and eigenfunctions, orthonormality, completeness and closure, generalized uncertainty principle, Unitary transformations, change of basis, Matrix Representation of operators, Continuous basis, position and momentum representation and their connection Parity operator.	*12 hours*
Module II	**Fundamental Concepts of Quantum Mechanics:** Basic postulates of quantum mechanics, Time evolution of system's state, Schrodinger, Heisenberg and interaction pictures, Density operator (Pure state and mixed state density operators), Discrete and continuous spectra in 1-D, Solution of 1-D harmonic oscillator using algebraic method	*11 hours*
Module III	**Angular Momentum:** Orbital, Spin and total angular momentum operators, Pauli spin matrices, their Commutation relations, Eigenvalues and eigenfunctions of L_2 and L_z, Angular momentum as generator of rotation, Addition of angular momenta, Clebsch-Gordon coefficients, L-S coupling.	*11 hours*
Module IV	**Pictures of representations:** Matrix theory of harmonic oscillator, Derivation of Hamiltonian of atomic electron in an em-field, Equation of election in uniform magnetic field.	*10 hours*

Module V	**Identical Particles:** Many particle systems, Systems of identical particles, Exchange degeneracy, Summarization postulate, construction of symmetric and anti-symmetric wave functions from unsymmetrized functions, The Pauli exclusion principle, Introduction to second quantization, Creation and annihilation operators for Fermions and Bosons, Fock states.	*12 hours*

Learning Resources:

Text Books and Reference Books :

1. " Principles of Quantum Mechanics, R. Shankar, Springer, 2nd edition 2011.
2. Quantum Mechanics: Concepts and Applications, Nouredine Zettili, Wiley india Pvt. Ltd, 2nd edition, 2016
3. Quantum Mechanics: A Modern Development, Leslie E. Ballentine, Wspc, 1st edition 1998.
4. Introduction to Quantum Mechanics, David J. Griffiths, Cambridge University Press, 2nd edition, 2016
5. Quantum Mechanics, Cohen-Tannoudji, Diu, and Laloë, Wiley VCH, 1st edition 1997

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PHCC705: *Classical Physics II (Credits:04)*

Course Objectives: This course aims to provide insight into Newtonian approaches to solving various physical phenomena, fundamentals of all physical sciences, and subsequently relatively modern and challenging topics like the mechanics of a system of particles at an advanced level.

- This structured approach ensures a thorough understanding of classical mechanics, preparing students for advanced topics in physics and engineering.
- To understand Hamilton's equations and canonical transformations, including generating functions, Legendre transformations, Routh's procedure, and the formalism of Poisson brackets, while exploring their applications in deriving invariants, the Jacobi identity, angular momentum relations, and Liouville's theorem.
- To explore Hamilton-Jacobi theory by analyzing the Hamilton-Jacobi equation, separation of variables, action-angle variables, and applying the formalism to problems such as harmonic oscillation and the Kepler problem, while drawing analogies between the Hamilton-Jacobi equation and the Schrödinger equation
- To examine the dynamics of rigid bodies by studying kinematics, Euler angles, the equations of motion, angular momentum, kinetic energy, the inertia tensor, principal axis transformation, and Euler's equations of motion.
- To analyze small oscillations through principal axis transformation and vibration frequencies, while also exploring the principles of special relativity, including Lorentz transformations, Minkowski space, four-vector formalism, and the metric tensor.

Course Outcomes (CO): The outcome of this course enriches students to correlate with:

CO1: Deal with fundamentals of Newtonian mechanics, principle of work done in equilibrium state, formulation of Lagrangian and Hamiltonian and its deduction.

CO2: Understanding of generating function as a function of generalized coordinates, discussion on the dynamic of the system in cyclic or canonical condition and mathematical method to analyses canonical transformation.

CO3: Introduction to the Hamilton-Jacobi method to define system dynamics in a new coordinate system and its applications.

CO4: The concept of reduced mass to deal with many body problems and kinematics to solve problems in rigid body dynamics.

CO5: Analyze classical problems, such as the harmonic oscillator problem, using advanced mathematical approaches.

Course Code: PHCC705	Classical Physics II	L-T-P:C 3-1-0: 4
Module I	**Introductory To Newtonian Mechanics (Lagrangian And Hamiltonian):** Coordinate systems, Generalized coordinates, Degree of freedom, Constraints, Principal of Virtual Work, D'Alembert's principal and its applications, Lagrange's equation and its applications, virial theorem, Calculus of variations: Hamilton's principle, Lagrange's equations from Hamilton's principle, Method of Lagrange's multipliers for non-holonomic systems, cyclic coordinates, conservation theorems and symmetry principles, Noether's theorem	*12 hours*
Module II	**Hamilton's Equations and Canonical Transformations:** Generating function, Legendre transformation, Hamilton equations of motion, Routh's procedure, Canonical transformation and its examples, Lagrange, Poisson, and other canonical invariants, Infinitesimal canonical theorem in Poisson bracket formalism, Jacobi identity, Angular momentum Poisson bracket relations, Liouville's theorem.	*12 hours*
Module III	**Hamilton-Jacobi Theory:** The Hamilton-Jacobi equation, Separation of variable in Hamilton-Jacobi equation; Acton-angle variables one degree of freedom. Applications of H-J formalism: Harmonic oscillation, Kepler's problem, analogy between Hamilton – Jacobi equation and Schrödinger equation.	*10 hours*
Module IV	**Rigid Body Dynamics:** The kinematics of rigid body motion: the Euler angles, Euler's theorem on the motion of a rigid body, the rigid body equations of motion: angular momentum and kinetic energy of motion about a point, the inertia tensor and the moment of inertia, the principal axis transformation, the Euler equations of motion.	*10 hours*
Module IV	**Small oscillations and Special Theory of Relativity:** Formulation of the problem, principal axis transformation, frequencies of free vibrations and normal coordinators, forced vibrations and the effect of dissipative forces. Lorentz Transformations. Minkowski space, Four-vector formalism, metric tensor.	*12 hours*

Learning Resources:

Text Books and Reference Books :

1. Classical Mechanics, Herbert Goldstein, Charles Poole, and John Safko, Pearson Education, 3rd edition, 2011.
2. Mechanics, L.D. Landau and E.M. Lifshitz, Butterworth-Heinemann, 3rd edition 1998.
3. Classical Mechanics, David Morin, Cambridge University Press, 1st edition, 2008.
4. An Introduction to Mechanics, Daniel Kleppner and Robert Kolenkow, McGraw Hill Education, 1st edition 2017.
5. Classical Mechanics, John R. Taylor, Cup, 2008.

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Semester VII (Practical)

PHCC702: General Physics Lab III (Credits:02)

Course Objectives:

This course introduces the practical's related to Basic Physics Principles and their applications.

Course Outcomes (CO):

The practical knowledge of mechanics doing experiments. They would also learn optical phenomena such as diffraction, refraction, and dispersion and do experiments related to optical devices: Prism, grating, and rectangular slabs.

Complete any seven practicals from the given experiments:

Sl. No.	Title of the experiments
1	*To measure the magnetic field for circular conductor loops.*
2	*To verify the existence of discrete atomic energy levels and to evaluate the quantum of energy transfer from electron beam to atoms by Frank Hertz experiment.*
3	*To find the value of Planks constant (h) using a photo cell.*
4	*To determine the electronic charge by using rectifier equation in case point contact Germanium rectifier.*
5	*To analyze waves (Square, Triangular, clipped sine wave) using Fourier analysis kit.*
6	*Determine Boltzmann constant by P–N junction diode and hence find the value of of LED.*
7	*Determination of stopping potential of the material of photo cell & determination of maximum kinetic energy of the photoelectron*
8	*Study the elastic and plastic extension of material wires.*

Learning Resources:

Text Books:

1. Engineering Practical Physics, S.Panigrahi and B. Mallick, Cengage learning, 2015.
2. B. Sc. Practical Physics, C.L. Arora, S. Chand Publishing, 2010.
3. B. Sc. Practical Physics, by H. Singh, P. S. Hemne, S. Chand Publishing, 2022.

Online Resources:

https://www.vlab.co.in/participating-institute-amrita-vishwa-vidyapeetham

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Semester VII (Minor Course)

PHMC701: *Research Methodology (Credits:03)*

Course Objectives:

This course aims to learn different methods to formulate a research work.

- To Study the basic definition of the research problem.
- To Study the basic concepts of research design and ethics.
- To study the basic concepts of data analysis.
- To study the basic use of computer applications.

Course Outcomes (CO):

After completion of the course, students will be able to:

CO1: Analyze the basics of research formulation.

CO2: Explain the basics of research formulation, and research ethics.

CO3: Define the basic concept of error analysis.

CO4: Identify the basic role of computer applications in the area of research.

Course Code: PHMC701	***Research Methodology***	***L-T-P:C 3-0-0: 3***
Module I	**Definition of the problem**: identifying and formulating the problem, techniques involved in solving the problem: (a) exact analytical solutions of equations involved, (b) numerically solving equations, (c) simulating the problem on a computer, Monte Carlo or molecular dynamics approach, (d) experimental observations and theoretical modelling.	*10 hours*
Module II	**Research design and ethics:** review of research literature, purpose and use of literature review, locating relevant information, uses of library and electronic databases, identification of gaps in research, formulation of research problem, definition of research objective, preparation and presentation of literature review, theoretical models and frame work, scientific ethics, copyrights and plagiarism.	*10 hours*
Module III	**Analyzing data:** errors and analysis of errors, introductory probability and stochastic processes, descriptive statistics and correlations.	*8 hours*
Module IV	**Using computers in research:** Handling different operating systems, (a)literature survey using web, handling search engines, (b) computer usage for collecting/analyzing data, simulations using Fortran/ C++ /Mathematica/MATLAB/Molden, (c) preparation of research articles, thesis and presentation, research papers: using word processing software-MS Word/Latex/others, drawing graphs and diagrams-Origin/Statistica/Excel/others, seminar presentations-Power point or oral and poster presentations.	*14 hours*

Learning Resources:

Text Books:

1. How to Write and Publish, R. A. Day and B. Gastel, Greenwood Press, 7th edition, 2011.
2. Probability and Statistics for Engineers and Scientists, S. Ross, Academic Press, 2009.
3. Research Methodology: Methods and Techniques, C. R. Kothari, New Age International Publishers, Fourth edition, 2019.
4. Data Reduction and Error Analysis for Physical Sciences, P.R. Bevington and D.K. Robinson, McGraw-Hill Education, 3rd edition, 2002

Semester VIII (Core Course)

PHCC801: Lasers Technology (Credits:03)

Course Objectives: - This course aims to provide insight into fundamentals of concept of laser, different types of lasers, and its application in various fields which include:

- Basic structure and working principle of laser
- Understanding and basic properties of laser
- It offers the capability of elementary problem-solving in laser optics
- Relating theoretical predictions and measurement of results
- Application of quantum concepts in harmonic oscillators, electromagnetic fields, etc.

Course Outcomes (CO): The outcome of this course enriches student to correlate with:

CO1: Identify the fundamental concepts of absorption and emission of light, laser properties, and study of different types of lasers.

CO2: Identify the factors involve in enhancing the performance of the laser.

CO3: Analyze and solve simple problems related to lasers

CO4: Formulate new methods to study laser and its classification

CO5: Demonstrate knowledge of laser and its applications

Course Code: PHCC801	*Lasers Technology*	*L-T-P:C 3-0-0: 3*
Module I	**Fundamental of Laser:** Quantum behavior of light, development of laser, concept: energy levels, population levels; Absorption and emission of light, Einstein relations. Condition of stimulated emission and light amplification, Idea of population Inversion, pumping schemes, classification of lasers, Components of a laser. Two-level and three-level Laser rate equations.	*10 hours*
Module II	**Mode:** Optical Gain, Line Broadening Mechanism, Bandwidth, Modes of a laser with emphasis on single mode operation, properties of modes, optimization of output power. Intensity, directionality, monochromaticity, polarization and speckles.	*9 hours*
Module III	**Laser Amplifiers:** Output control of lasers, Selection of narrow frequency range, Selection of TEM Modes. And single longitudinal modes. Idea of generating high power pulse.	*8 hours*
Module IV	**Q-Switching:** Concept of Q-factor, Q-switching for obtaining giant pulses, different methods of Q-switching. Cavity dumping, mode locking techniques frequency conversion using non- linear crystals, Idea of tunable Lasers.	*8 hours*
Module V	**Application:** Applications of lasers in: Civil, Mechanical, Electrical, Electronics, Laboratory studies, Medical Science, Military applications, automobiles, Aeronautics and space science.	*7 hours*

Learning Resources:

Text Books and Reference Books :

1. Laser Fundamentals, William T. Silfvast, Cambridge University Press, 2nd edition, 2008.
2. Lasers: Principles, Types, and Applications, K. Thyagarajan, Laxmi Publications, Second edition, 2019.
3. Optical Fiber Communications, Gerd Keiser, McGraw Hill Education, Fifth edition, 2017.
4. Laser Physics, Peter W. Milonni and Joseph H. Eberly, Wiley, 1st edition, 2010.

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Semester VIII (Core Course)

PHCC803: Energy Studies (Credits:03)

Course Objectives: - The course will enable students to approach energy issues in a sophisticated and scientific fashion and basic concept of energy.

- To understand Energy and its Uses.
- To understand Sources of Energy
- Study the flow of energy
- To understand the concept of system and synthesis.

Course Outcomes (CO): The outcome of this course enriches student to correlate with:

CO1: Identify the fundamental concepts of Units and scales of energy use, Mechanical energy and transport, Heat energy: Conversion between heat and mechanical energy, Electromagnetic energy, etc.

CO2: To attain knowledge of the basics of Fundamental forces in the universe.

CO3: To acquire more knowledge of the flow of energy by understanding the basics of solar radiation etc.

CO4: Gain knowledge on the concept of nuclear radiation, climate change, energy storage and conversion.

Course Code: PHCC803	*Energy Studies*	*L-T-P:C 3-0-0: 3*
Module I	**Energy and its Uses:** Units and scales of energy use, Mechanical energy and transport, Heat energy: Conversion between heat and mechanical energy, Electromagnetic energy: Storage, conversion, transmission and radiation, Intro to the quantum, energy quantization, Energy in chemical systems and processes, flow of CO_2, Entropy and temperature, Heat engines, Phase change energy conversion, refrigeration and heat pumps, Internal combustion engines,	*13 hours*
Module II	**Sources of Energy:** Fundamental forces in the universe, Quantum mechanics relevant for nuclear physics, Nuclear forces, energy scales and structure, nuclear binding energy systematics, reactions and decays, nuclear fusion and fission, nuclear fission reactor design, safety, operation and fuel cycles.	*10 hours*
Module III	**The flow of energy in the universe:** Solar radiation, Absorption and thermal utilization, Solar-thermal electricity, Photovoltaics (PV), Advanced PV, overview, Fluid dynamics and power in the wind, available resources, viscosity, types of fluid flow, Wind turbine dynamics and design, wind farms Geothermal power and ocean thermal energy conversion, Tidal/wave/hydro power	*12 hours*
Module IV	**Systems and Synthesis:** Nuclear radiation, fuel cycles, waste and proliferation, Climate change, Energy storage, Energy conservation.	*7 hours*

Learning Resources:

Text Books:

1. Climate Change and Sustainable Transportation, A. S. Khati and P. G. Dastidar, The Energy and Resources Institute, TERI, 2019.
2. Energy Studies, D.William Shepherd and W. Shepherd, Imperial college press, 2nd edition, 2004.
3. Concepts of Modern Physics, A Beiser, McGraw Hill, 6th edition, 2003.
4. Introduction to Quantum Mechanics, David J. Griffiths, Cambridge University Press, 2nd edition, 2016.

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Semester VIII (Minor Course)

PHCC805: Modern Physics (Credits:02)

Course Objectives: - This course aims to provide a brief insight into the bridge between the classical and modern approaches to various physical phenomena and diverse perspectives of advanced methods.

- Discuss on postulate of matter wave duality.
- Idea of uncertainty in measurement.
- Quantum behavior of a particle in indefinite rigid box.
- Structure of atom and interaction prevalent within.

Course Outcomes (CO): Outcome of this course enrich student to correlate with:

CO1: Study of investigation and evidence of wave-particle dualism of photon.

CO2: Understanding the behavior of quantum particle and rising of uncertainty of measurement, versatility of Schrodinger equation to define the wave behavior accurately, and basic postulate of wave behavior of light.

CO3: Generalized theory and mathematical approaches to understanding the quantization of energy state of particle in infinite rigid potential box and mechanism involve in the production of highly monochromic beam.

CO4: Concept involves interaction of electron-electron, proton-electron, etc. and its method to determine the interaction within atom.

Course Code: PHMC805	*Modern Physics*	*L-T-P:C 2-0-0: 2*
Module I	**Postulate of Matter-Wave Duality:** Planck's quantum, Blackbody Radiation, Photo-electric effect, and Compton scattering. De Broglie wavelength, Davisson-Germer experiment. Wave description of particles by wave packets, Group and Phase velocities and the relation between them, Double-slit experiment, Probability, Wave amplitude, and wave functions.	*8 hours*
Module II	**Principle of Uncertainty:** Position measurement- gamma-ray microscope thought experiment; Wave-particle duality, Heisenberg uncertainty principle, Derivation from Wave Packets impossibility of a particle following a trajectory; Two slit interference experiment with photons, atoms and particles; linear superposition principle as a consequence; Matter waves and wave amplitude; Schrodinger equation; Momentum and Energy operators; stationary states; physical interpretation of a wave function, Physical Acceptability of Wave Functions, normalization; Probability and probability current densities in one dimension.	*8 hours*

Module III	**One Dimensional Infinitely Rigid Box**: energy Eigen values, Eigen functions and their normalization; Quantum dot as an example; Quantum mechanical scattering and tunneling in one dimension across a step potential & across a rectangular potential barrier. Lasers: Metastable states, Spontaneous, and Stimulated emissions, Optical Pumping and Population Inversion.	*6 hours*
Module IV	**Structure of Atom:** Size of the atom, Impossibility of an electron being in the nucleus as a consequence of the uncertainty principle. Nature of nuclear force, N-Z graph, Liquid Drop model: semi-empirical mass formula and binding energy.	*6 hours*

Learning Resources:

Text Books:

1. Modern Physics, Kenneth S. Krane, John Wiley & Sons, 3rd edition, 2012.
2. Modern Physics for Scientists and Engineers, Stephen T. Thornton and Andrew Re, Brooks/Cole, 5th edition, 2020.
3. Introduction to Modern Physics, Richard Wolfson, Pearson, 3rd edition, 1999.
4. Concepts of Modern Physics, Arthur Beiser, Medtech science, 2024.
5. Modern Physics, Paul A. Tipler and Ralph A. Llewellyn, W. H. Freeman, 5th Edition, 2007.

Reference Books:

1. Modern Physics for Scientists and Engineers, Thornton, Stephen T., and Rex, Andrew, Cengage Learning, 2009.

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Semester VIII (Core Course)

PHCC807: *Electrodynamics II (Credits:04)*

Course Objectives:

- Introduce electrostatic principles, focusing on solving Poisson's and Laplace's equations, boundary value problems, and forces on dielectrics.
- Teach the fundamentals of electrostatics, magnetostatics, and Maxwell's equations for understanding wave propagation in different media.
- Explore plane electromagnetic waves, polarization, wave reflection/refraction, and wave propagation in conductors and dielectrics.
- Study the radiation from oscillating sources, electric dipole fields, and their applications to radio wave transmission.
- Examine radiation emitted by accelerating charges, focusing on Lienard-Wiechert potentials and power radiated by moving charges.

Course Outcomes (CO):
The outcome of this course enriches students to correlate with:

CO1: Understand the solutions to Poisson's and Laplace's equations, apply boundary conditions, and analyze forces in dielectric materials.

CO2: Apply Gauss's law, Ampere's law and Maxwell's equations to describe electrostatic and magnetostatic phenomena and electromagnetic wave propagation.

CO3: Analyze plane wave propagation, polarization, and Fresnel equations, with applications to waveguides and resonant cavities.

CO4: Understand radiation from dipoles and oscillating sources, applying it to fields like radio wave communication.

CO5: Apply the Lienard-Wiechert potentials and Larmor's formula to describe radiation from accelerating charges and compute radiated power.

Course Code: PHCC807	***Electrodynamics II***	***L-T-P:C 3-1-0: 4***
Module I	**Electrostatics and Boundary value problems:** Poisson's and Laplace's equation in cartesian, spherical coordinate system and its solution, uniqueness theorem, method of images, separation of variables, multipole expansion, polarization, field of a polarized object, electric displacement, boundary conditions for D and E, dielectric constant, boundary value problems, energy, forces on dielectrics	*13 hours*
Module II	**Electrostatics, Magnetostatics and Electrodynamics:** Gauss's law, Boundary value problems, multipoles, dielectrics, Biot and Savart law, Ampere's law, Faraday's law, Displacement current, Maxwell's equations, Wave propagation in Conductors and Dielectrics	*13 hours*

Module III	**Plane Electromagnetic Waves and Wave Propagation:** Plane Waves in Non-conducting Medium Linear and Circular Polarization, Stokes Parameter, Reflection and Refraction of Electromagnetic Waves at a Plane Interface between Dielectrics, Fresnel Equation, Group Velocity Dispersion (GVD), Kramers-Kronig Relations. **Waveguides and Resonant Cavities:** Field sat the surface of and within a Conductor; Cylindrical Cavities and Wave Guides, Resonant Cavities, Power losses in a Cavity and Q of a Cavity.	*14 hours*
Module IV	**Simple Radiating Systems and Diffraction:** Fields of Radiation of localized oscillating Source, Electric Dipole fields and radiation and its application to radio waves.	*9 hours*
Module V	**Radiation by moving Charges:** Lienard-Wiechertz Potentials and Fields for a Point Charge, Total power Radiated by an Accelerating charge, Larmor's formula.	*7 hours*

Learning Resources:

Text Books and Reference Books :

1. Principles of Quantum Mechanics, R. Shankar, Springer, 2nd edition, 1994.
2. Quantum Mechanics: Concepts and Applications, Nouredine Zettili, Wiley india Pvt. Ltd, 2nd edition 2016
3. Quantum Mechanics: A Modern Development, Leslie E. Ballentine, World Scientific Publishing Co Pte Ltd, 1998
4. Introduction to Quantum Mechanics, David J. Griffiths, Cambridge University Press, 3rd edition, 2018.
5. Quantum Mechanics, Cohen-Tannoudji, Diu, and Laloë, Wiley-VCH, 2nd edition, 2019.

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Semester VIII (Core Course)

PHCC809: Quantum Mechanics II (Credits:04)

Course Objectives: - The aim of this course is to provide insight into variational principles, Quantum scattering and relativistic Quantum Mechanics of sub-atomic particles.

- Overview of physics beyond classical mechanics and formalism of quantum mechanics.
- Discuss the fundamental concept of quantum mechanics.
- Use of mathematical tools to solve quantum problems.
- Application of quantum concept in harmonic oscillator, electromagnetic field, etc.
- Gives an idea of the degeneracy of many particle systems, symmetric and unsymmetric wave functions.

Course Outcomes (CO): Outcome of this course enrich student to correlate with:

CO1: Identify the fundamental concepts of approximations in quantum mechanics

CO2: Solve and explain different problems related to the dynamics of subatomic particles.

CO3: Comprehensive knowledge of scattering theory and systematic analyses of the effect through different methods.

CO4: Formulate new methods to solve relativistic quantum mechanical problems

CO5: Contribution and approach of Dirac formalism in solving different quantum problems.

Course Code: PHCC809	***Quantum Mechanics II***	***L-T-P:C 3-1-0: 4***
Module I	**Approximation methods for stationary systems:** Time independent perturbation theory, Perturbation of non-degenerate states: first and second order perturbation, Perturbation of a harmonic oscillator, Perturbation of degenerate states, removal of degeneracy, Zeeman and Stark effects, Variational and WKB methods.	*12 hours*
Module II	**Approximation methods for non-stationary systems:** Schrodinger, Heisenberg and interaction pictures, Equations of Motion, Constant and harmonic perturbation, Discrete and continuous case, transition probability, Fermi golden rule, Adiabatic and sudden approximations.	*12 hours*
Module III	**Scattering Theory:** Scattering of a wave packet, The differential and total Cross section, The Born approximation, Partial waves and phase shifts, The Lippmann Schwinger equation, Definition and properties of S-matrix, T-matrix, Optical theorem	*12 hours*
Module IV	**Relativistic Quantum Mechanics:** Klein-Gordon, Dirac equations and properties of Dirac matrices, Lorentz and CPT invariance of Dirac equation, Non-relativistic reduction of the Dirac equation, Central forces and the hydrogen atom.	*12 hours*

Module V	**Solution to Dirac Equation:** Free particle solution, Hydrogen atom in Dirac's theory, Dirac electron in constant magnetic field, Foldy-Wouthuysen transformation, Hole theory.	*6 hours*

Learning Resources:

Text Books:

1. Classical Electrodynamics ,John David Jackson, wily,3rd edition,2007
2. Introduction to Electrodynamics ,David J. Griffiths, Pearson Education India Learning Pvt.Ltd,4td edition,2005
3. Electrodynamics: A Modern Approach ,David H. Frisch and John C. McLennan
4. The Classical Theory of Fields, L.D. Landau and E.M. Lifshitz, Butterworth-Heinemann,4th edition,1980
5. Electromagnetic Fields, John A. Stratton, Wiley-IEEE Press,1st edition,2007

Reference Books:

1. Classical Electrodynamics , Jackson, John David, Wiley, 1999.
2. Introduction to Electrodynamics, Griffiths, David J. Pearson, 2013.
3. The Classical Theory of Fields. Landau, L.D. and Lifshitz, E.M. Pergamon Press, 1975.

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Semester VIII (Minor Course)

PHCC811: Statistical Mechanics (Credits:04)

Course Objectives: -

- Introduce key concepts of thermodynamics, including entropy, phase space, and energy distribution in classical systems.
- Teach the formulation and applications of microcanonical, canonical, and grand canonical ensembles and their relation to partition functions.
- Explore blackbody radiation and the quantum corrections to classical radiation theories like Rayleigh-Jeans.
- Introduce quantum statistics through Bose-Einstein and Fermi-Dirac distributions and quantum mechanical ensemble theory.
- Apply quantum statistical mechanics to systems such as ideal Bose and Fermi gases, Bose-Einstein condensation, and electron gas in metals.

Course Outcomes (CO): The outcome of this course enriches students to correlate with:

CO1: Explain thermodynamic laws, equilibrium, and the statistical interpretation of entropy and energy distribution.

CO2: Master ensemble theory and partition functions to derive thermodynamic quantities for different systems.

CO3: Explain key laws of blackbody radiation, resolving classical failures with Planck's quantum theory.

CO4: Differentiate between classical and quantum statistical distributions, applying them to quantum systems like particles in a box.

CO5: Analyze quantum gases and related phenomena, such as Bose-Einstein condensation, Pauli Para magnetism, and electron behavior in metals.

Course Code: PHMC811	*Statistical Mechanics*	*L-T-P:C 3-1-0: 4*
Module I	**Statistical Basis of Thermodynamics:** Quasistatic and non-quasi static processes, laws of thermodynamics, entropy of a probability distribution, random walks - Langevin' Theory of Brownian Motion, entropy, phase space, Liouville's theorem postulates of statistical mechanics, system in thermodynamic equilibrium, law of equipartition of energy and its applications, classical ideal gas, Gibb's paradox.	*13 hours*
Module II	**Ensemble Theory:** Microcanonical, canonical and grand canonical ensembles and partition functions. Maxwell's Boltzmann's distribution, Gibb's formulation for canonical and grand canonical ensembles, partition function, their thermodynamic properties	*10 hours*
Module III	**Theory of Radiation:** Properties of Thermal Radiation. Blackbody Radiation. Pure temperature dependence. Kirchhoff's law. Stefan-Boltzmann law: Thermodynamic proof. Radiation Pressure. Wien's Displacement law. Wien's Distribution Law. Saha's Ionization Formula. Rayleigh-Jeans Law. Ultraviolet Catastrophe. Planck's Quantum Theory of Black body radiation, Experimental verification and deduction of Planck's law of Radiation,	*12 hours*

Module IV	**Quantum Statistics:** Drawbacks of M B distribution, Bose-Einstein's and Fermi-Dirac distribution, symmetric and antisymmetric particles, non-degenerate, weakly degenerate and strongly degenerate, Quantum mechanical ensemble theory, Density Matrix, Statistics of various ensembles, examples: Free particle in a box, harmonic Oscillator, Theory of Simple Gases: Ideal gas in different quantum mechanical ensembles.	*12 hours*
Module V	**Application of Quantum Statistics:** Ideal Bose Gas: Thermodynamics, Bose-Einstein Condensation, Blackbody Radiation, Phonons, Ideal Fermi Gas: Thermodynamics, Pauli Para magnetism, Landau diamagnetism, Electron gas in metals.	*9 hours*

Learning Resources:

Text Books and Reference Books:

1. Statistical Mechanics R.K. Pathria, Paul D. Beale., Academic Press Inc, 3rd Edition,2011.
2. Statistical Mechanics, Franz Mandl, Wiley India Pvt Ltd, 2nd Edition,2014.
3. Introduction to Modern Statistical Mechanics, David Chandler, Oxford Univ Press, 1987.
4. Statistical Mechanics: Theory and Applications, B. K. Agarwal,M. Ganesh, New Age International Private Limited, 2020.

Students for a 4-year ***UG Degree (Honors)*** *need to complete additional* ***(3, 3, 2) Credits*** *major/minor courses in place of* ***MOOC*** *courses or need to complete additional* ***(4, 4, 4) Credits*** *major courses in place of Project.*

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