Department of Physics

Bachelor of Science (Hons.) in Physics
OR
Bachelor of Science (Hons.) with Research in Physics

based on NEP-2020

(Effective from academic session 2022-2023)

Academic Advisory Committee (AAC)

S. No	Members
1	Dr D. K. Avasthi, Dean R&D Research, UPES Dehradun, External Member
2	Prof V. D. Vankar, Ex-Professor, Department of Physics, IIT Delhi
3	Prof H. M. Agrawal, Ex-Professor, Department of Physics, GB Pant University
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6	Dr Archana Mishra, Member, Assistant Professor, Department of Physics
7	Dr Indira Pandey, Member, Assistant Professor, Department of Physics
8	Dr Gaurav Upadhyay, Member, Assistant Professor, Department of Physics

1. Introduction to Undergraduate Degree course in Physics

The undergraduate degree course in Physics is a six/eight semester course spread over three/ four academic years. The teaching – learning process is student-centric and it involves both theory and practical components. It offers a flexibility of programme structure while ensuring that the student gets a strong foundation in the subject and gains in-depth knowledge. There is the combination of courses that include DSC (discipline specific core course), DSE (discipline specific elective courses), GE (generic elective courses), SECs, AECs and VACs. Thereby, bringing out the multidisciplinary approach and adherence to innovative ways within the curriculum framework. Moreover, it allows a student maximum flexibility in pursuing his/her studies at the undergraduate level to the extent of having the liberty to eventually design the degree with multiple exit options depending upon the needs and aspirations of the student in terms of his/her goals of life, without compromising on the teaching learning, both in qualitative and quantitative terms. This will suit the present day needs of students in terms of securing their paths towards higher studies or employment.

2. Program Objectives:

- To motivate and inspire the students to create deep interest in Physics.
- To develop broad and balanced knowledge and understanding of physical concepts, principles
- and theories of Physics.
- To learn, design and perform experiments in the labs to demonstrate the concepts, principles and theories learned in the classrooms.
- To develop the ability to apply the knowledge acquired in the classroom and laboratories to specific problems in theoretical and experimental Physics.
- To provide the student the vast scope of Physics as a theoretical and experimental science with applications in solving most of the problems in nature
- To emphasize the discipline of Physics to be the most important branch of science for pursuing the interdisciplinary and multidisciplinary higher education and/or research in interdisciplinary and multidisciplinary areas.
- To emphasize the importance of Physics as the most important discipline for sustaining the existing industries and establishing new ones to create job opportunities at all levels of employment.
- Sufficient subject matter competence and enable students to prepare for various competitive examinations such as IIT-JAM, GATE, GRE, UGC-CSIR NET/JRF and Civil Services Examinations.

3. Program Outcomes:

The student graduating with the undergraduate degree in Physics should be able to

- Acquire

1. a fundamental/systematic or coherent understanding of the academic field of Physics, its different learning areas and applications in basic Physics like Materials science, Nuclear and Particle Physics, Condensed matter Physics, Atomic and Molecular Physics, Mathematical Physics, Analytical dynamics, Bio Physics, and its linkages with related disciplinary areas/subjects like Chemistry, Mathematics, Environmental sciences, Computer science,Information Technology;
2. procedural knowledge that creates different types of professionals related to the disciplinary/subject area

of Physics, including professionals engaged in research and development, teaching and government/public service;

- Demonstrate the ability to use skills in Physics and its related areas of technology for formulating and tackling Physics-related problems.

- Recognize the importance of mathematical modeling simulation and computing, and the role of approximation and mathematical approaches to describing the physical world.

- Plan and execute Physics-related experiments or investigations, analyze and interpret data/information collected using appropriate methods, including the use of appropriate software such as programming languages and purpose-written packages.

- Demonstrate relevant generic skills and global competencies such as

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

2. investigative skills, including skills of independent investigation of Physics-related issues and problems, communication skills involving the ability to listen carefully, to read texts and research papers analytically and to present complex information.

4. Programme Duration and Exit Options

The minimum credits to be earned by the student per semester are 22 credits. This provision is meant to provide students the comfort of the flexibility of semester-wise academic load and to learn at his/her own pace. However, the mandatory number of credits which have to be secured for the purpose of award of Undergraduate Certificate/ Undergraduate Diploma/Appropriate Bachelor's Degree in Physics are listed in Table 1.

Table 1: Award with credit requirement

S. No.	Name of Award	Stage of Exit	Mandatory
1	Undergraduate certificate in Physics	After successful completion of Semester II	44
2	Undergraduate diploma in Physics	After successful completion of Semester IV	88
3	Bachelor of Science Physics (Hons.)	After successful completion of Semester VI	132
4	Bachelor of Science Physics (Hons. with Research	After successful completion of Semester VIII	176
5	Bachelor of Science Physics (Hons.) with Research in Physics (Major) and Discipline - 2 (Minor)	After successful completion of Semester VIII with minimum 28 GE credits in discipline -2 (minor)	176

Major Discipline (Physics)

A student pursuing four-year undergraduate programme in Physics (Core course) shall be awarded B.Sc. Honours degree with Major in Physics on completion of VIII Semester, if he/she secures in Physics at least 50% of the total credits i.e., at least 88 credits in Physics out of the total of 176 credits. He/she shall study 20 DSCs and at least 2 DSEs of Physics in eight semesters.

Minor Discipline (Discipline - 2)

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 seven GE courses of that discipline.

5. Definitions and Abbreviations

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

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

1. **Discipline Specific Core (DSC):** Discipline Specific Core is a course of study, which should be pursued by a student as a mandatory requirement of his/ her programme of study. In Bachelor of Science (Hons.) Physics programme, DSCs are the core credit courses of Physics which will be appropriately graded and arranged across the semesters of study, being undertaken by the student, with multiple exit options as per NEP 2020. A student will study three DSC courses each in Semesters I to VI; and one DSC course each in semesters VII and VIII.
2. **Discipline Specific Elective (DSE):** The Discipline Specific Electives (DSEs) are a pool of credit courses of Physics from which a student will choose to study based on his/ her interest. A student of Bachelor of Science (Hons.) Physics, gets an option of choosing one DSE of Physics in each of the semesters III to VI, while the student has an option of choosing a maximum of three DSE courses of Physics in semesters VII and VIII.
3. **Generic Elective (GE):** Generic Electives is a pool of courses offered by various disciplines of study (excluding the GEs offered by the parent discipline) which is meant to provide multidisciplinary or interdisciplinary education to students. In case a student opts for DSEs beyond his/ her discipline specific course(s) of study, such DSEs shall be treated as GEs for that student.
4. **Skill Enhancement Courses (SECs)** are skill-based courses in all disciplines and are aimed at providing hands-on training, competencies, proficiency and skills to students. SEC courses may be chosen from a pool of courses designed to provide skill-based instruction. A student will study one Skill Enhancement Course of 2 credits each (following 1T+ 1P/ 0T+2P credit system) in all the semesters from I to VI. It is to be noted that in the semesters III, IV, V and VI; students can choose either one SEC paper or can join any Internship/ Apprenticeship/ Project (following two credit system).
5. **Ability Enhancement Course (AEC)** are the courses based upon the content that leads to

knowledge enhancement through various areas of study. They are Language and Literature and Environmental Science and Sustainable Development which are mandatory for all disciplines. Every student has to study "Environmental Science and Sustainable Development" courses I and II of two credits each in the first year (I/ II semester) and the second year (III/ IV semester), respectively.

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

6. Programme and Frame Work

Semester	Discipline Specific Core Course	Discipline Specific Elective (DSE)/ Generic Elective (GE)	Ability Enhancement Course (AEC)	Skill Enhancement Course (SEC)/ Project/ Dissertation	Value Addition Course (VAC)	Total Credits earned
1.	DSC1: Mathematical Physics I DSC2: Fundamental Topics of Physics DSC3: Mechanics	DSE1/GE1	AEC1	SEC1	VAC1	22
2.	DSC4: Electricity and Magnetism DSC5: Waves and Oscillations DSC6: Electrical Circuit Analysis	DSE2/GE2	AEC2	SEC2	VAC2	22
3.	DSC7: Mathematical Physics II DSC8: Thermal Physics DSC9: Analog systems and Applications	DSE3/GE3	AEC3	SEC3	VAC3	22
4.	DSC10: Mathematical Physics III DSC11: Elements of Modern Physics DSC12: Digital Systems and Applications	DSE4/GE4	AEC4	SEC4	VAC4	22
5.	DSC13: Quantum Physics I DSC14: Electromagnetic Theory DSC15: Nuclear Physics	DSE5/GE5 DSE6/GE6		Internship/Apprenticeship/ Project/Community Outreach(2 Credits)		22
6.	DSC16: Solid State Physics DSC17: Statistical Physics DSC18: Computational Physics	DSE7/GE7 DSE8/GE8		Internship/Apprenticeship/ Project/Community Outreach(2 Credits)		22
7.	DSC19: Classical Mechanics	DSE9/GE9 DSE10/GE10 DSE11/GE11		Dissertation / Academic Project (6 Credits)		22
8.	DSC20: Quantum Physics II	DSE12/GE12 DSE13/GE13 DSE14/GE14		Dissertation / Academic Project (6 Credits)		22

The detailed framework of undergraduate degree programme in Physics is provided in following Table 2.

Table 2: Semester-wise Course Frame Work

S. No.	Course Code	Course Type	Name of the Course	L	T	P	Total Credits
Semester I							
1	PHC101	DSC 1	Mathematical Physics I	3	0	1	4
2	PHC102	DSC 2	Fundamental Topics of Physics	3	1	0	4
3	PHC103	DSC 3	Mechanics	3	0	1	4
4		GE1	choose from the pool of courses*	3	1	0	4
5		SEC 1	choose from the pool of courses**				2
6		AEC 1	choose from the pool of courses offered by the University				2
7		VAC 1	choose from the pool of courses offered by the University				2
Total Credits 22							
Semester II							
1	PHC151	DSC 4	Electricity and Magnetism	3	0	1	4
2	PHC152	DSC 5	Waves and Oscillations	3	0	1	4
3	PHC153	DSC 6	Electrical Circuit Analysis	3	1	0	4
4		GE 2	choose from the pool of courses*				4
5		SEC 2	choose from the pool of courses**				2
6		AEC 2	choose from the pool of courses offered by the University				2
7		VAC 2	choose from the pool of courses offered by the University				2
Total Credits 22							
Exit option after one year with 44 credits to get Undergraduate Certificate in Physics							
Semester III							
1	PHC201	DSC 7	Mathematical Physics II	3	0	1	4
2	PHC202	DSC 8	Thermal Physics	3	0	1	4
3	PHC203	DSC 9	Analog systems and	3	0	1	4

			Applications				
4		GE3/DSE1	choose from the pool of courses*	3	1	0	4
5		SEC 3	choose from the pool of courses**				2
6		AEC 3	choose from the pool of courses offered by the University				2
7		VAC 3	choose from the pool of courses offered by the University				2
							Total Credits 22
			Semester IV				
1	PHC251	DSC 10	Mathematical Physics III	3	0	1	4
2	PHC252	DSC 11	Elements of Modern Physics	3	0	1	4
3	PHC253	DSC 12	Digital System and Applications	3	0	1	4
4		GE4/DSE2	choose from the pool of courses*				4
5		SEC 4	choose from the pool of courses**				2
6		AEC 4	choose from the pool of courses offered by the University				2
7		VAC 4	choose from the pool of courses offered by the University				2
							Total Credits 22
Exit option after Two years with 88 credits to get Undergraduate Diploma in Physics							
			Semester V				
1	PHC301	DSC 13	Quantum Physics I	3	1	0	4
2	PHC302	DSC 14	Electromagnetic Theory	3	0	1	4
3	PHC303	DSC 15	Nuclear Physics	3	0	1	4
4 5		GE5/DSE3	Choose 1 GE and 1 DSE from the pool of courses*				4 4
6	PHI301/PHP301/PHO301	Internship/Project/community outreach					2
							Total Credits 22
			Semester VI				
1	PHC351	DSC 16	Solid State Physics	3	0	1	4
2	PHC352	DSC 17	Statistical Physics	3	0	1	4

3	PHC353	DSC 18	Computational Physics	3	0	1	4
4 5		GE6/DSE4	Choose GE/DSE from the pool of courses*				4 4
6	PHI351/PHP351/PHO 351	Internship/Project/ community outreach					2
							Total Credits 22
Exit option after three years with 132 credits to award the degree of B.Sc (Honours) in Physics if he/she earned 80 credits (from 18 DSC's and 2 DSE's) in Physics							
			Semester VII				
1	PHC401	DSC 19	Classical Mechanics	3	1	0	4
2 3 4		GE/DSE*	Choose three DSE courses OR Choose two DSE and one GE courses OR Choose one DSE and two GE courses				4 4 4
5	PHD401	Dissertation (Part-1)					6
							Total Credits 22
			Semester VIII				
1	PHC451	DSC 20	Quantum Physics II	3	1	0	4
2 3 4		GE/DSE	Choose three DSE courses OR Choose two DSE and one GE courses OR Choose one DSE and two GE courses				4 4 4
5	PHD451	Dissertation (Part-2)					6
							Total Credits 22
Exit option after Four years with 176 credits to award the degree of B.Sc (Honours with Research) in Physics and Minor (Discipline 2)							

6.1 Discipline Specific Core Papers (DSC): (Credit: 04 each)

A student will study three Discipline Specific Core Courses each in Semesters I to VI and one core course each in semesters VII and VIII. The semester wise distribution of DSC courses over eight semesters is listed in Table 3.

Table 3: Details of Discipline Specific Core (DSC) Courses

Course	Semester	Name of the Course
DSC1	I	Mathematical Physics I
DSC2	I	Fundamental Topics of Physics
DSC3	I	Mechanics
DSC4	II	Electricity and Magnetism
DSC5	II	Waves and Oscillations
DSC6	II	Electrical Circuit Analysis
DSC7	III	Mathematical Physics II
DSC8	III	Thermal Physics
DSC9	III	Analog systems and Applications
DSC10	IV	Mathematical Physics III
DSC11	IV	Elements of Modern Physics
DSC12	IV	Digital Systems and Applications
DSC13	V	Quantum Physics I
DSC14	V	Electromagnetic Theory
DSC15	V	Nuclear Physics
DSC16	VI	Solid State Physics
DSC17	VI	Statistical Physics
DSC18	VI	Computational Physics
DSC19	VII	Classical Mechanics
DSC20	VIII	Quantum Physics II

6.2 <u>Details of Discipline Specific Elective Papers: (4 credits each)</u>

The Discipline Specific Electives (DSEs) are a pool of credit courses offered by the Department of Physics from which a student will choose to study based on his/ her interest. A student of Bachelor of Science (Hons.) Physics gets an option of choosing one DSE of Physics in each of the semesters III to VI, while the student has an option of choosing a maximum of three DSE courses of Physics in semesters VII and VIII. The distribution of DSE courses is listed in Table 4.

Table 4: Pool of Discipline Specific Elective Courses (DSE)*

S. No.	Course Code	Name of the Course
1	PHE101	Advanced Mathematical Physics
2	PHE102	Biophysics
3	PHE103	Nano Materials and Applications
4	PHE104	Advanced Solid State Physics
5	PHE105	Physics of Materials
6	PHE106	Applied Dynamics
7	PHE107	Introduction to Particle Physics
8	PHE107	Astronomy and Astrophysics
9	PHE108	Physics of Devices and Instrumentation
10	PHE109	Medical Physics
11	PHE110	Earth Science
12	PHE111	Research Methodology
13	PHE112	Atmospheric Physics
14	PHE113	Optical Fiber Communication and Integrated Nonlinear Optics
15	PHE114	Experimental Techniques
16	PHE115	Applied Optics
17	PHE116	Elements of Spectroscopy

In addition to the above proposed courses, students may select courses from the **Swayam.org as MOOCs courses** upto the permissible limit.

6.3 Details of Skill Enhancement Courses (2 credits)**

In order to enhance the skills required for advanced studies, research and employability of students various Skill Enhancement Courses (SEC) will be offered to students that are listed in Table 5.

Table 5: Pool of Skill Enhancement Courses (SE)**

S. No	Course Code	Name of the Course
1	PHS101	Basics of Instrumentation
2	PHS102	Computational Physics Skills
3	PHS103	Physics Workshop Skills
4	PHS104	Scientific Writing
5	PHS105	Electrical circuit network Skills
6	PHS106	Sensors and Detectors Technology
7	PHS107	Renewable Energy and Energy Harvesting
8	PHS108	Mechanical Drawing

9	PHS109	Introduction to Lasers and Fiber Optics
10	PHS110	Radiation Safety
11	PHS111	Weather Forecasting
12	PHS112	Introduction To SCILAB Programming

In addition to the above proposed courses, students may select courses from the **Swayam.org as MOOCs courses** upto the permissible limit.

6.4 <u>Details of Generic Elective Courses (GE) (4 credits)*</u>

Generic Elective courses offer interdisciplinary education to students. Various generic elective courses offered by the Department of Physics are listed below in Table 6.

Table 6: Pool of Generic Elective Courses (GE)*

S. No	Course Code	Name of the Course
1	PHG101	Mechanics I
2	PHG102	Introduction to Electromagnetic Theory
3	PHG103	Digital, Analog circuits and Instrumentation
4	PHG104	Elements of Modern Physics
5	PHG105	Mechanics II
6	PHG106	Mathematical Physics I
7	PHG107	Thermal Physics
8	PHG108	Waves and Optics
9	PHG109	Mathematical Physics II
10	PHG110	Solid State Physics
12	PHG111	Quantum Mechanics
13	PHG112	Nuclear and Particle Physics

In addition to the above proposed courses, students may select courses from the **Swayam.org as MOOCs courses** upto the permissible limit.

DISCIPLINE SPECIFIC COURSES

SEMESTER I

PHC101: MATHEMATICAL PHYSICS I

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

Total Hours: Theory: 45, Practical: 30

L	T	P	Cr
3	0	1	4

Course Objectives:

The emphasis of course is on applications in solving problems of interest to physicists. The course will also expose students to fundamental computational physics skills enabling them to solve a wide range of physics problems. The skills developed during course will prepare them not only for doing fundamental and applied research but also for a wide variety of careers.

Course Outcomes:

After completing this course, student will be able to,

1. Understand the concept of divergence and curl of vector fields.
2. Perform line, surface and volume integration and apply Green's, Stokes' and Gauss's theorems to compute these integrals.
3. The students will be also enabled to apply these to physics problems.
4. Use curvilinear coordinates to problems with spherical and cylindrical symmetries.
5. Understand the concept of probability and apply these to physics problem.
6. Learn about the concept of Dirac Delta function.

Course Content:

UNIT 1

Calculus of functions of more than one variable: Partial derivatives, exact and inexact differentials. Integrating factor, with simple illustration. Constrained Maximization using Lagrange Multipliers. **(6 Lectures)**

UNIT 2

Vector Calculus:

Recapitulation of vectors: Properties of vectors under rotations. Scalar product and its invariance under rotations. Vector product, Scalar triple product and their interpretation in terms of area and volume respectively. Scalar and Vector fields. **(5 Lectures)**

Vector Differentiation: Directional derivatives and normal derivative. Gradient of a scalar field and its geometrical interpretation. Divergence and curl of a vector field. Del and Laplacian operators. Vector identities, Gradient, divergence, curl and Laplacian in spherical and cylindrical coordinates. **(9 Lectures)**

Vector Integration: Ordinary Integrals of Vectors. Multiple integrals, Jacobian. Notion of infinitesimal line, surface and volume elements. Line, surface and volume integrals of Vector fields. Flux of a vector field. Gauss' divergence theorem, Green's and Stokes Theorems and their applications (no rigorous proofs). **(14 Lectures)**

UNIT 3

Orthogonal Curvilinear Coordinates:

Orthogonal Curvilinear Coordinates. Derivation of Gradient, Divergence, Curl and Laplacian in Cartesian, Spherical and Cylindrical Coordinate Systems. **(6 Lectures)**

UNIT 4

Introduction to probability:

Independent random variable: Probability distribution functions, binomial, Gaussian and Poisson, with examples Mean and variance. **(3 lectures)**

UNIT 5

Dirac Delta function and its properties:

Definition of Dirac delta function. Representation as limit of a Gaussian function and rectangular function. Properties of Dirac delta function. **(2 Lectures)**

Reference Books:

- Mathematical Methods for Physicists, G.B. Arfken, H.J. Weber, F.E. Harris, 2013,7th Edn., Elsevier.
- An introduction to ordinary differential equations, E.A. Coddington, 2009, PHI learning
- Differential Equations, George F. Simmons, 2007, McGraw Hill.
- Mathematical Tools for Physics, James Nearing, 2010, Dover Publications.
- Mathematical methods for Scientists and Engineers, D.A. McQuarrie, 2003, Viva Book
- Advanced Engineering Mathematics, D.G. Zill and W.S. Wright, 5 Ed., 2012, Jones and Bartlett Learning
- Advanced Engineering Mathematics, Erwin Kreyszig, 2008, Wiley India.
- Essential Mathematical Methods, K.F. Riley & M. P. Hobson, 2011, Cambridge Univ. Press

PRACTICAL Mathematical Physics (Credit:01, 30 hours)

The aim of this Lab is to emphasize its role in solving problems in Physics.

Topics	Description with Applications
Introduction and Overview	Computer architecture and organization, memory and Input/output devices
Basics of scientific computing	Binary and decimal arithmetic, Floating point numbers, algorithms, Sequence, Selection and Repetition, single and double precision arithmetic, underflow & overflow- emphasize the importance of making equations in terms of dimensionless variables, Iterative methods
Errors and error Analysis	Truncation and round off errors, Absolute and relative errors, Floating point computations.
Review of C++ /PYTHON/ FORTRAN Programming fundamentals	Introduction to Programming, constants, variables and data types, operators and Expressions, I/O statements, scanf and printf, c in and c out, Manipulators for data formatting, Control statements (decision making and looping statements) (*If-statement. If-else Statement. Nested if Structure. Else-if Statement. TernaryOperator. Goto Statement. Switch Statement. Unconditional and Conditional Looping. While Loop. Do-While Loop. FOR Loop. Break and Continue Statements. Nested Loops*), Arrays (*1D & 2D*) and strings, user defined functions, Structures and Unions, Idea of classes and objects
Programs:	Sum & average of a list of numbers, largest of a given list of numbers and its location in the list, sorting of numbers in ascending descending order, Binary search
Random number generation	Area of circle, area of square, volume of sphere, value of π
Solution of Algebraic and Transcendental equations by Bisection, Newton Raphson and Secant methods	Solution of linear and quadratic equation, solving $\alpha = \tan\alpha$; $I = I_O[(\sin\alpha)/\alpha]^2$ in optics
Interpolation by Newton Gregory Forward and Backward difference formula, Error estimation of linear interpolation	Evaluation of trigonometric functions e.g. *sin θ, cos θ, tan θ, etc.*
Numerical differentiation (Forward and Backward difference formula) and Integration (Trapezoidal and Simpson rules), Monte Carlo method	Given Position with equidistant time data to calculate velocity and acceleration and vice versa. Find the area of B-H Hysteresis loop

Referred Books:

- Introduction to Numerical Analysis, S.S. Sastry, 5th Edn., 2012, PHI Learning Pvt.Ltd.
- Schaum's Outline of Programming with C++. J. Hubbard, 2000, McGraw-Hill Pub.
- Numerical Recipes in C: The Art of Scientific Computing, W.H. Pressetal, 3rdEdn., 2007, Cambridge University Press.
- A first course in Numerical Methods, U.M. Ascher&C. Greif,2012, PHILearning.
- Elementary Numerical Analysis, K.E. Atkinson, 3 rd Edn., 2007, Wiley India Edition.
- Numerical Methods for Scientists & Engineers, R.W. Hamming, 1973, Courier Dover Pub.
- An Introduction to computational Physics, T. Pang, 2ndEdn., 2006, Cambridge Univ. Press

PHC102: FUNDAMENTAL TOPICS OF PHYSICS

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

Total Hours: Theory: 45, Tutorial: 15

L	T	P	Cr
3	1	0	4

Course Objectives:

This course reviews the concepts of mathematical Physics and mechanics learnt at school from a more advanced perspective and goes on to build new concepts. The students will review about the concepts of electricity in more generalized form.

Course Learning Outcome:

Upon completion of this course, students will be able to,

1. Learn about the first and second order differential equations.
2. Understand the fundamentals of mechanics.
3. Learn the concepts of conservative and non-conservative fields and forces and able to solve Physics problems based on that.
4. Understand the advanced concepts of electric field, electric forces and potential.
5. Apply Coulomb's law to line, surface, and volume distributions of charges.
6. Apply Gauss's law of electrostatics to distribution of charges.
7. Solve the boundry value problem based on electric potential and field.

Course Content:

UNIT 1

First and Second Order Differential equations: Homogeneous Equations with constant coefficients. Wronskian and general solution. Statement of existence and Uniqueness Theorem for Initial Value Problems. Particular Integral.

(13 Lectures)

UNIT 2

Fundamentals of Dynamics: Reference frames. Inertial frames; Galilean transformations; Galilean invariance. Review of Newton's Laws of Motion. Dynamics of a system of particles. Centre of Mass. Principle of conservation of momentum. Impulse. Momentum of variable-mass system: motion of rocket.

(9 Lectures)

UNIT 3

Work and Energy: Work and Kinetic Energy Theorem. Conservative and nonconservative forces. Potential Energy. Energy diagram. Stable and unstable equilibrium. Elastic potential energy. Force as gradient of potential energy. Work & Potential energy. Work done by non-conservative forces. Law of conservation of Energy.

(6 Lectures)

UNIT 4

Electric Field and Electric Potential: Electric field: Electric field lines. Electric flux. Gauss' Law with applications to charge distributions with spherical, cylindrical and planar symmetry. **(6 Lectures)**

Conservative nature of Electrostatic Field. Electrostatic Potential. Laplace's and Poisson equations. The Uniqueness Theorem. Potential and Electric Field of a dipole. Force and Torque on a dipole. **(7 Lectures)**

UNIT 5

Electric Field in Matter: Polarization in matter, Bound charges and their physical interpretation. Field inside a dielectric, Displacement vector D, Gauss' Law in the presence of dielectrics, Boundary conditions for D, Linear dielectrics, Electric Susceptibility and Dielectric Constant, idea of complex dielectric constant due to varying electric field. Boundary value problems with linear dielectrics **(6 Lectures)**

Reference Books:

- An introduction to mechanics, D. Kleppner, R.J. Kolenkow, 1973, McGraw-Hill.
- Mechanics, Berkeley Physics, vol.1, C. Kittel, W. Knight, et.al. 2007, Tata McGraw-Hill.
- Physics, Resnick, Halliday and Walker 8/e. 2008, Wiley.
- Analytical Mechanics, G.R. Fowles and G.L. Cassiday. 2005, Cengage Learning.
- Feynman Lectures, Vol. I, R.P. Feynman, R.B. Leighton, M. Sands, 2008, Pearson Education
- Introduction to Special Relativity, R. Resnick, 2005, John Wiley andSons.
  University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.

Additional Books for Reference

- Mechanics, D.S. Mathur, S. Chand and Company Limited,2000
- University Physics. F.W Sears, M.W Zemansky, H.D Young 13/e, 1986, Addison Wesley
- Physics for scientists and Engineers with Modern Phys., J.W. Jewett, R.A. Serway, 2010, Cengage Learning
- Theoretical Mechanics, M.R. Spiegel, 2006, Tata McGraw Hill.

PHC103: MECHANICS

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

Total Hours: Theory: 45, Practical: 30

L	T	P	Cr
3	0	1	4

Course Objectives:

This course reviews the concepts of mechanics learnt at school from a more advanced perspective and goes on to build new concepts. It begins with Newton's Laws of Motion and ends with the Special Theory of Relativity. The students will learn the collisions in the centre of mass frame, rotational motion and central forces. They will be able to apply the concepts learnt to several real-world problems.

In the laboratory part of the course, the students will learn to use various instruments, estimate the error for every experiment performed and report the result of experiment along with the uncertainty in the result up to correct significant figures.

Course Learning Outcome:

Upon completion of this course, students will be able to,

1. Understand translational and rotational dynamics of a system of particles.
2. Apply Kepler's laws to describe the motion of planets and satellite in circular orbit.
3. Understand about Fundamental ideas of special theory of relativity such aslength contraction and time dilation and mass –energy invariance
4. Use various instruments for measurements and perform experiments related to rotational dynamics, elastic properties, fluid dynamics, acceleration due to gravity, collisions, etc.
5. Use propagation of errors to estimate uncertainty in the outcome of an experiment and perform the statistical analysis of the random errors in the observations.
6. Students.
7. Students develop ability to perform experiments and develop understanding about gravity, angular momentum, Moment of Inertia and elastic property.
8. Experimental demonstration of above discussed topics will help them to develop understanding of basic physics in their daily life.

Course Content:

UNIT 1

Rotational Dynamics: Angular momentum of a particle and system of particles. Torque. Principle of conservation of angular momentum. Rotation about a fixed axis. Moment of Inertia. Calculation of moment of inertia for rectangular, cylindrical and spherical bodies. Kinetic energy of rotation. Motion involving both translation and rotation. **(12 Lectures)**

UNIT 2

Collision: Elastic and inelastic collisions between particles. Center of mass and laboratory frames. **(3 lectures)**

UNIT 3

Oscillations: SHM: Simple Harmonic Oscillations. Differential equation of SHM and its solution. Kinetic energy, potential energy, total energy and their time-average values. Damped oscillation. Forced oscillations: Transient and steady states; Resonance, sharpness of resonance; power dissipation and Quality Factor.

(7 lectures)

UNIT 4

Gravitation and Central Force Motion: Law of gravitation. Gravitational potential energy. Inertial and gravitational mass. Potential and field due to spherical shell and solid sphere. **(4 Lectures)**

Motion of a particle under a central force field. Two-body problem and its reduction to one-body problem and its solution. The energy equation and energy diagram. Kepler's Laws. Satellite in circular orbit and applications. Geosynchronous orbits. Weightlessness. Basic idea of global positioning system (GPS). Physiological effects on astronauts.

(6 Lectures)

UNIT 5

Non-Inertial Systems: Non-inertial frames and fictitious forces. Uniformly rotating frame. Laws of Physics in rotating coordinate systems. Centrifugal force. Coriolis force and its applications. Components of Velocity and Acceleration in Cylindrical and Spherical Coordinate Systems. **(4 Lectures)**

UNIT 6

Special Theory of Relativity: Michelson-Morley Experiment and its outcome. Postulates of Special Theory of Relativity. Lorentz Transformations. Simultaneity and order of events. Lorentz contraction. Time dilation. Relativistic transformation of velocity, frequency and wave number. Relativistic addition of velocities. Variation of mass with velocity. Massless Particles. Mass-energy Equivalence. Relativistic Doppler effect. Relativistic Kinematics. Transformation of Energy and Momentum. Energy- Momentum Four Vector.

(9 Lectures)

Reference Books:

- An introduction to mechanics, D. Kleppner, R.J. Kolenkow, 1973, McGraw-Hill.
- Mechanics, Berkeley Physics, vol.1, C. Kittel, W. Knight, et.al. 2007, Tata McGraw-Hill.
- Physics, Resnick, Halliday and Walker 8/e. 2008, Wiley.
- Analytical Mechanics, G.R. Fowles and G.L. Cassiday. 2005, Cengage Learning.
- Feynman Lectures, Vol. I, R.P. Feynman, R.B. Leighton, M. Sands, 2008, Pearson Education
- Introduction to Special Relativity, R. Resnick, 2005, John Wiley and Sons.University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.

Additional Books for Reference

- Mechanics, D.S. Mathur, S. Chand and Company Limited, 2000
- University Physics. F.W Sears, M.W Zemansky, H.D Young 13/e, 1986, Addison Wesley
- Physics for scientists and Engineers with Modern Phys., J.W. Jewett, R.A. Serway, 2010, Cengage Learning
- Theoretical Mechanics, M.R. Spiegel, 2006, Tata McGraw Hill.

PRACTICAL Mechanics (Credit:01, 30 hours)

Every student must perform at least 05 experiments

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

Reference Books

- Advanced Practical Physics for students, B. L. Flint and H.T. Worsnop, 1971, Asia Publishing House
- Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
- A Text Book of Practical Physics, I. Prakash & Ramakrishna, 11th Edn, 2011, Kitab Mahal

SEMESTER II

PHC151: ELECTRICITY AND MAGNETISM

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

Total Hours: Theory: 45, Practical: 30

L	T	P	Cr
3	0	1	4

Course Objectives:

1. To learn the concepts of charge, fields and potentials and how do they interact with each other.
2. To be able to use the basic laws of Laplace's and Poisson's equations.
3. To learn concepts of magnetic fields and use them to estimate field due to various structure like solenoid, toroid.
4. To learn the concepts of electromagnetic induction and its applications.

Course Outcomes:

After going through the course, student should be able to

1. Explain and determine electric field and potential due various charge configuration. Explain gauss's law and use it to determine electric field.
2. Explain the concept of Capacitor's and use the method of images and determine potential due to various charge distributions.
3. Explain the concept of magnetic fields, and determine field due to solenoid and toroid.
4. Explain the concept of electromagnetic induction, and its application in various electric instruments, describe various electric circuit and determine their reactance and impedance. Explain the concept and use of ballistic galvanometer.
5. Experimental demonstration of above discussed topics will help them to develop understanding of basic physics in their daily life.

Course Content:

UNIT 1

Electrostatic energy of system of charges. Electrostatic energy of a charged sphere. Conductors in an electrostatic Field. Surface charge and force on a conductor. Capacitance of a system of charged conductors. Parallel-plate capacitor. Capacitance of an isolated conductor. Method of Images and its application to: (1) Plane Infinite Sheet and (2) Sphere. **(12 Lectures)**

Special techniques for the calculation of Potential and Field: The Method of Images is applied to a system of a point charge and finite continuous charge distribution (line charge and surface charge) in the presence of (i) a Plane infinite sheet maintained at constant potential, and (ii) a Sphere maintained at constant potential. **(5 Lectures)**

Multipole Expansion: Monopole, dipole and quadrupole potentials at large distances due to an arbitrary charge distribution expressed in terms of Legendre polynomials, negative Gradient of Dipole potential in spherical coordinates. **(5 Lectures)**

UNIT 2

Magnetic Field: Magnetic force between current elements and definition of Magnetic Field **B**. Biot-Savart's Law and its simple applications: straight wire and circular loop. Current Loop as a Magnetic Dipole and its Dipole Moment (Analogy with Electric Dipole). Ampere's Circuital Law and its application to (1) Solenoid and (2) Toroid. Properties of **B**: curl and divergence. Vector Potential. Magnetic Force on (1) point charge (2) current carrying wire (3) between current elements. Torque on a current loop in a uniform Magnetic Field.
(12 Lectures)

UNIT 3

Electromagnetic Induction: Faraday's Law. Lenz's Law. Self-Inductance and Mutual Inductance. Reciprocity Theorem. Energy stored in a Magnetic Field. Introduction to Maxwell's Equations. Charge Conservation and Displacement current. **(7 Lectures)**

UNIT 4

Electrical Circuits: AC Circuits: Kirchhoff's laws for AC circuits. Complex Reactance and Impedance. Series LCR Circuit: (1) Resonance, (2) Power Dissipation and (3) Quality Factor, and (4) Band Width. Parallel LCR Circuit. **(4 Lectures)**

Reference Books:

- Electricity, Magnetism & Electromagnetic Theory, S. Mahajan and Choudhury, 2012, TataMc Graw
- Electricity and Magnetism, Edward M. Purcell, 1986 McGraw-Hill Education
- Introduction to Electrodynamics, D.J. Griffiths, 3rd Edn., 1998, Benjamin Cummings.
- Feynman Lectures Vol.2, R.P. Feynman, R.B. Leighton, M. Sands, 2008, Pearson Education
- Elements of Electromagnetics, M.N.O. Sadiku, 2010, Oxford University Press.
- Electricity and Magnetism, J.H. Fewkes & J. Yarwood. Vol. I, 1991, Oxford Univ. Press.

PRACTICAL Electricity and Magnetism (Credit:01, 30 hours)

Every student must perform at least 05 experiments

1. Use a Multimeter for measuring (a) Resistances, (b) AC and DC Voltages, (c) DC

Current, (d) Capacitances, and (e) Checking electrical fuses.

2. To study the characteristics of a series RC Circuit.
3. To determine an unknown Low Resistance using Potentiometer.
4. To determine an unknown Low Resistance using Carey Foster's Bridge.
5. To compare capacitances using De'Sauty's bridge.
6. Measurement of field strength B and its variation in a solenoid (determined B/dx)
7. To verify the Thevenin and Norton theorems.
8. To verify the Superposition, and Maximum power transfer theorems.
9. To determine self inductance of a coil by Anderson's bridge.
10. To study response curve of a Series LCR circuit and determine its (a) Resonant frequency, (b) Impedance at resonance, (c) Quality factor Q, and (d) Bandwidth.
11. To study the response curve of a parallel LCR circuit and determine its (a) Anti-resonant frequency and (b) Quality factor Q.
12. Measurement of charge and current sensitivity and CDR of Ballistic Galvanometer.
13. Determine a high resistance by leakage method using Ballistic Galvanometer.
14. To determine self-inductance of a coil by Rayleigh's method.
15. To determine the mutual inductance of two coils by Absolute method.

Reference Books

- Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, AsiaPublishing House
- A Text Book of Practical Physics, I.Prakash & Ramakrishna, 11th Ed., 2011,KitabMahal
- Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition,reprinted 1985, Heinemann Educational Publishers
- A Laboratory Manual of Physics for undergraduate classes, D.P. Khandelwal, 1985,VaniPub.

PHC152: WAVES AND OSCILLATIONS

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

Total Hours: Theory: 45, Practical: 30

L	T	P	Cr
3	0	1	4

Course Objectives:

1. To introduce basic concepts of wave motion and principle of superposition
2. To understand the mathematical oscillator equation and wave equation and derive these equations for certain systems.
3. To able to use the concepts of Interference, diffraction and polarization in wave optical applications
4. To Explain several phenomena, we can observe in everyday life that can be explainedas wave phenomena.

Course Outcomes:

After going the course, the student should be able to

1. Describe examples of oscillating systems, describe superposition principle and its application in explaining beats and concepts of phase and group velocities.
2. Explain Lissajous's Figure's and their use in determining frequency ratio of two signals.
3. Explain wave motions, its components, its type, and able to write wave equation.
4. Explain electromagnetic waves, principle of interference, diffraction and difference between them.

Course Content:

UNIT 1

Superposition of Collinear Harmonic oscillations: Linearity and Superposition Principle. Superposition of two collinear oscillations having (1) equal frequencies and (2) different frequencies (Beats). Superposition of N collinear Harmonic Oscillations with (1) equal phase differences and (2) equal frequency differences.

(6 Lectures)

Superposition of two perpendicular Harmonic Oscillations: Graphical and Analytical Methods. Lissajous Figures (1:1 and 1:2) and their uses. **(2 Lectures)**

UNIT 2

Wave Motion: Plane and Spherical Waves. Longitudinal and Transverse Waves. Plane Progressive (Travelling) Waves. Wave Equation. Particle and Wave Velocities. Differential Equation. Pressure of a Longitudinal Wave. Energy Transport. Intensity of Wave. Water Waves: Ripple and Gravity Waves.

(4 Lectures)

UNIT 3

Velocity of Waves: Velocity of Transverse Vibrations of Stretched Strings. Velocity of Longitudinal Waves in a Fluid in a Pipe. Newton's Formula for Velocity of Sound. Laplace's Correction. **(6 Lectures)**

UNIT 4

Superposition of Two Harmonic Waves: Standing (Stationary) Waves in a String: Fixed and Free Ends. Analytical Treatment. Phase and Group Velocities. Changes with respect to Position and Time. Energy of Vibrating String. Transfer of Energy. Normal Modes of Stretched Strings. Plucked and Struck Strings. Melde's Experiment. Longitudinal Standing Waves and Normal Modes. Open and Closed Pipes. Superposition of N Harmonic Waves. **(8 Lectures)**

UNIT 5

Wave Optics: Electromagnetic nature of light. Definition and properties of wave front. Huygens Principle. Temporal and Spatial Coherence. **(3 Lectures)**

Interference: Division of amplitude and wavefront. Young's double slit experiment. Lloyd's Mirror and Fresnel's Biprism. Phase change on reflection: Stokes' treatment. Interference in Thin Films: parallel and wedge-shaped films. Fringes of equal inclination (Haidinger Fringes); Fringes of equal thickness (Fizeau Fringes). Newton's Rings: Measurement of wavelength and refractive index. **(10 Lectures)**

Interferometer: Michelson Interferometer-(1) Idea of form of fringes (No theory required), (2) Determination of Wavelength, (3) Wavelength Difference, (4) Refractive Index, and (5) Visibility of Fringes. Fabry-Perot interferometer. **(4 Lectures)**

Diffraction: Kirchhoff's Integral Theorem, Fresnel-Kirchhoff's Integral formula and its application to rectangular slit. **(2 Lectures)**

Reference Books

- Waves: Berkeley Physics Course, vol. 3, Francis Crawford, 2007, TataMcGraw-Hill.
- Fundamentals of Optics, F.A. Jenkins and H.E. White, 1981, McGraw-Hill
- Principles of Optics, Max Born and Emil Wolf, 7th Edn., 1999, Pergamon Press.
- Optics, Ajoy Ghatak, 2008, Tata McGrawHill
- The Physics of Vibrations and Waves, H. J. Pain, 2013, John Wiley and Sons

- The Physics of Waves and Oscillations, N.K. Bajaj, 1998, Tata McGrawHill.
- Oscillations, Waves & optics, H.M. Agrawal and R.M. Agrawal, Pearson, 2019.

PRACTICAL Waves and Optics (Credit:01, 30 hours)

Every student must perform at least 5 experiments

1. To determine the frequency of an electric tuning fork by Melde's experiment and verify λ^2 –T law.
2. To investigate the motion of coupled oscillators.
3. To study Lissajous Figures.
4. Familiarization with: Schuster`s focusing; determination of angle of prism.
5. To determine refractive index of the Material of a prism using sodium source.
6. To determine the dispersive power and Cauchy constants of the material of a prism using mercury source.
7. To determine the wavelength of sodium source using Michelson's interferometer.
8. To determine wavelength of sodium light using Fresnel Biprism.
9. To determine wavelength of sodium light using Newton's Rings.
10. To determine the thickness of a thin paper by measuring the width of the interference fringes produced by a wedge-shaped Film.
11. To determine wavelength of (1) Na source and (2) spectral lines of Hg source using plane diffraction grating.
12. To determine dispersive power and resolving power of a plane diffraction grating.

Reference Books

- Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, AsiaPublishing House
- A Text Book of Practical Physics, I. Prakash & Ramakrishna, 11th Ed., 2011, KitabMahal
- Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition,reprinted 1985, Heinemann Educational Publishers
- A Laboratory Manual of Physics for undergraduate classes, D. P. Khandelwal, 1985, Vani Pub.

PHC153: ELECTRICAL CIRCUIT ANALYSIS

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

Total Hours: Theory: 45, Practical: 30

L	T	P	Cr
3	0	1	4

Course Objectives:

This course covers the basic circuit concepts in a systematic manner which is suitable for analysis and design. It aims at study and analysis of electric circuits using network theorems and two-port parameters. Course Learning Outcomes: At the end of the course the student will be able to

1. Understand the basic concepts, basic laws and methods of analysis of DC and AC networks and their difference.
2. Solve complex electric circuits using network theorems.
3. Discuss resonance in series and parallel circuits and also the importance of initial conditions and their evaluation.
4. Evaluate the performance of two port networks.

Course Outcomes:

At the end of the course the student will be able to

1. Understand the basic concepts, basic laws and methods of analysis of DC and AC networks and their difference
2. Solve complex electric circuits using network theorems.
3. Discuss resonance in series and parallel circuits and also the importance of initial conditions and their evaluation.
4. Evaluate the performance of two port networks.

Course Content

UNIT 1

Circuit Analysis: Ideal voltage source, real voltage source, current source, Kirchhoff's current law, Kirchhoff's voltage law, node analysis, mesh analysis, Star and Delta conversion. DC Transient Analysis: Charging and discharging with initial charge in RC circuit, RL circuit with initial current, time constant, RL and RC Circuits with source. **(10 Lectures)**

UNIT 2

AC Circuit Analysis: Sinusoidal voltage and current, Definitions of instantaneous, peak to peak, root mean square and average values, form factor and peak factor (for half-rectified and full-rectified sinusoidal wave, rectangular wave and triangular wave), voltage-current relationship in resistor, inductor and capacitor, phasor, complex impedance, power in AC circuits, sinusoidal circuit analysis for RL, RC and RLC Circuits, resonance in series and parallel RLC Circuits (Frequency Response, Bandwidth, Quality Factor), selectivity, application of resonant circuits. **(10 Lectures)**

UNIT 3

Network Theorems: Principal of duality, Superposition theorem, Thevenin theorem, Norton theorem. Their applications in DC and AC circuits with more than one source, Maximum Power Transfer theorem for AC circuits, Reciprocity Theorem, Millman's Theorem, Tellegen's theorem.
Two Port Networks: Impedance (Z) Parameters, Admittance (Y) Parameters, Transmission Parameters, Impedance matching. **(10 Lectures)**

References:

Essential Readings:

- Electric Circuits, S. A. Nasar, Schaum's outline series, Tata McGraw Hill (2004)
- Essentials of Circuit Analysis, Robert L. Boylestad, Pearson Education (2004)
- Electrical Circuits, M. Nahvi and J. Edminister, Schaum's Outline Series, Tata McGrawHill (2005)
- Fundamentals of Electric Circuits, C. Alexander and M. Sadiku, McGraw Hill (2008)

Additional Reading:

- Network analysis, M. E. Van Valkenburg, Third edition, Prentice Hall

PRACTICAL Electrical Circuit Analysis (Credit:01, 30 hours)

Every student must perform at least five experiments

1. Verification of Kirchoff's Law.
2. Verification of Maximum Power Transfer Theorem.
3. Determination of time constant of RC and RL circuit
4. Study of frequency response of RC circuit
5. Study of frequency response of a series and parallel LCR Circuit and determination of its resonant frequency, impedance at resonance, quality factor and bandwidth.
6. Explore electrical properties of matter using Arduino:
   a. To study the characteristics of a series RC Circuit.
   b. To study the response curve of a Series LCR circuit and determine its resonant frequency, impedance at resonance, quality factor and bandwidth

References:

- A Textbook of Electrical Technology, B. L. Thareja, A.K. Thareja, Volume II, S. Chand
- Fundamentals of Electric Circuits, C. Alexander and M. Sadiku, McGraw Hill (2008)
- Electric Circuits, S. A. Nasar, Schaum's outline series, Tata McGraw Hill (2004)
- Electrical Circuits, K.A. Smith and R.E. Alley, 2014, Cambridge University Press
- Electrical Circuit Analysis, K. Mahadevan and C. Chitran, 2nd Edition, 2018, PHI learning Pvt. Ltd.

SEMESTER III

PHC201: MATHEMATICAL PHYSICS II

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

Total Hours: Theory: 45, Practical: 30

L	T	P	Cr
3	0	1	4

Course Objectives:

The objective of the course is to make the student understand about

1. Fourier series, periodic functions and their analysis.
2. Applications of Fourier analysis in physical systems.
3. Special functions and Frobenius method and its applications to differential equations.
4. Understand about theory of errors and partial differential equations.

Course Outcomes:

After the successful completion of the course, the student will learn:

1. Fourier analysis of periodic functions and their applications in physical problems such as vibrating strings etc.
2. about the special functions, such as the Hermite polynomial, the Legendre polynomial, the Laguerre polynomial and Bessel functions and their differential equations and their applications in various physical problems such as in quantum mechanics which they will learn in future courses in detail.
3. about the beta, gamma and the error functions and their applications in doing integrations.
4. Acquire knowledge of methods to solve partial differential equations with the examples of important partial differential equations in Physics.
5. In the laboratory course, learn the basics of the Scilab software, their utility,advantages and disadvantages

Course Content

UNIT 1

Complex Analysis: Brief Revision of Complex Numbers and their Graphical Representation. Euler's formula, De Moivre's theorem, Roots of Complex Numbers. Functions of Complex Variables. Analyticity and Cauchy-Riemann Conditions. Examples of analytic functions. Singular functions: poles and branch points, order of singularity, branch cuts. Integration of a function of a complex variable. Cauchy's Inequality. Cauchy’s Integral formula. Simply and multiply connected region. Laurent and Taylor’s expansion. Residues and Residue Theorem. Application in solving Definite Integrals. (**28 lectures**)

UNIT 2

Fourier Series: Periodic functions. Orthogonality of sine and cosine functions, Dirichlet Conditions (Statement only). Expansion of periodic functions in a series of sine and cosine functions and determination of Fourier coefficients. Complex representation of Fourier series. Expansion of functions with arbitrary period. Expansion of non-periodic functions over an interval. Even and odd functions and their Fourier expansions. Application. Summing of Infinite Series. Term-by-Term differentiation and integration of Fourier Series. Parseval Identity. (**13 Lectures**)

UNIT 3

Theory of Errors: Systematic and Random Errors. Propagation of Errors. Normal Law of Errors. Standard and Probable Error. (**4 Lectures**)

Reference Books:

- Mathematical Methods for Physicists: Arfken, Weber, 2005, Harris, Elsevier.
- Fourier Analysis by M.R. Spiegel, 2004, Tata McGraw-Hill.
- Mathematics for Physicists, Susan M. Lea, 2004, Thomson Brooks/Cole.
- Differential Equations, George F. Simmons, 2006, Tata McGraw-Hill.

PRACTICAL Mathematical Physics II (Credit:01, 30 hours)

Topics	Description with Applications

Introduction to Numerical computation software Scilab	Introduction to Scilab, Advantages and disadvantages, Scilab environment, Command window, Figure window, Edit window, Variables and arrays, Initialising variables in Scilab, Multidimensional arrays, Subarray, Special values, Displaying output data, data file, Scalar and array operations, Hierarchy of operations, Built in Scilab functions, Introduction to plotting, 2D and 3D plotting (2), Branching Statements and program design, Relational & logical operators, the while loop, for loop, details of loop operations, break & continue statements, nested loops, logical arrays and vectorization (2) User defined functions, Introduction to Scilab functions Variable passing in Scilab, optional arguments, preserving data between calls to a function, Complex and Character data, string function, Multidimensional arrays (2) an introduction to Scilab file processing, file opening and closing, Binary I/o functions, comparing binary and formatted functions, Numerical methods and developing the skills of writing a program(2).
Curve fitting, Least square fit, Goodness of fit, standard deviation	Ohms law to calculate R, Hooke's law to calculatespring Constant
Solution of Linear system of equations by Gauss elimination method and GaussSeidal method. Diagonalization of matrices, Inverse of a matrix, Eigen vectors, eigen values problems	Solution of mesh equations of electric circuits (3meshes)Solution of coupled spring mass systems (3masses)

Solution of ODE
First order Differential equation Euler, modified Euler and Runge-Kutta secondorder methods
Second order differential equation
Fixed difference method
	First order differential equation
	• Radioactive decay
	• Current in RC, LC circuits with DC source
	• Newton's law of cooling
	• Classical equations of motionSecond order Differential Equation
	• Harmonic oscillator (no friction)
	• Damped Harmonic oscillator
	  • Over damped
	  • Critical damped
	  • Oscillatory
	• Forced Harmonic oscillator
	  • Transient and
	  • Steady state solution

	Apply above to LCR circuits also
Using Scicos / xcos	• Generating square wave, sine wave, saw toothwave • Solution to harmonic oscillator • Study of beat phenomenon Phase space plots

Reference Books:

- Mathematical Methods for Physics and Engineers, K.F Riley, M.P. Hobson and S.J. Bence, 3rd ed., 2006, Cambridge University Press
- Complex Variables, A.S. Fokas & M.J. Ablowitz, 8th Ed., 2011, Cambridge Univ. Press
- First course in complex analysis with applications, D.G. Zill and P.D. Shanahan, 1940, Jones &Bartlett
- Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific and Engineering Applications: A.V. Wouwer, P. Saucez, C.V. Fernández. 2014 Springer
- Scilab by example: M. Affouf 2012, ISBN:978-1479203444
- Scilab (A free software to Matlab): H. Ramchandran, A.S.Nair. 2011 S.Chand & Company
- Scilab Image Processing: Lambert M. Surhone. 2010 Betascript Publishing

PHC202: THERMAL PHYSICS

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

Total Hours: Theory: 45, Practical: 30

L	T	P	Cr
3	0	1	4

Course Objectives:

The objective of this course is to build-up basic understanding of

1. concepts of work, power, and heat in thermodynamics; determine work and heat sign conventions; determine work involved with moving boundary systems (graphical and analytical methods which will develop understanding of mass, energy, heat, work, efficiency, ideal and real thermodynamic cycles and processes.
2. first laws of thermodynamics, perfect gas law, properties of real gases, and the general energy equation for closed systems.
3. necessary the second law of thermodynamics, including why and how it is defined (Kelvin-Planck and Clausius), the nature of irreversibility, and the Carnot cycle.

Course Outcomes:

After successful completion of the course, the student will

1. become familiar with various thermodynamic process and work done in each of these processes.
2. have a clear understanding about reversible and irreversible process and also working of a Carnot engine, and knowledge of calculating change in entropy for various process.
3. Realize the importance of thermodynamical functions and applications of Maxwell's relations.
4. Perform energy analysis of refrigeration and heat pump thermodynamic cycles.
5. become familiar with kinetic theory of Gasses (behaviour of real gas).

Course Content

UNIT 1

Introduction to Thermodynamics

Zeroth and First Law of Thermodynamics: Extensive and intensive Thermodynamic Variables, Thermodynamic Equilibrium, Zeroth Law of Thermodynamics & Concept of Temperature, Concept of Work & Heat, State Functions, First Law of Thermodynamics and its differential form, Internal Energy, First Law & various processes, Applications of First Law: General Relation between C_P and C_V, Work Done during Isothermal and Adiabatic Processes, Compressibility and Expansion Co-efficient.**(8 Lectures)**

Second Law of Thermodynamics: Reversible and Irreversible process with examples. Conversion of Work into Heat and Heat into Work. Heat Engines. Carnot's Cycle, Carnot engine & efficiency. Refrigerator & coefficient of performance, 2^{nd} Law of Thermodynamics: Kelvin-Planck and Clausius Statements and their Equivalence. Carnot's Theorem. Applications of Second Law of Thermodynamics: Thermodynamic Scale of Temperature and its Equivalence to Perfect Gas Scale. **(10 Lectures)**

Entropy: Concept of Entropy, Clausius Theorem. Clausius Inequality, Second Law of Thermodynamics in terms of Entropy. Entropy of a perfect gas. Principle of Increase of Entropy. Entropy Changes in Reversible and Irreversible processes with examples. Entropy of the Universe. Entropy Changes in Reversible and Irreversible Processes. Principle of Increase of Entropy. Temperature–Entropy diagrams for Carnot's Cycle.
Third Law of Thermodynamics. Unattainability of Absolute Zero. **(7 Lectures)**

Thermodynamic Potentials: Extensive and Intensive Thermodynamic Variables. Thermodynamic Potentials: Internal Energy, Enthalpy, Helmholtz Free Energy, Gibb's Free Energy. Their Definitions, Properties and Applications. Surface Films and Variation of Surface Tension with Temperature. Magnetic Work, Cooling due to adiabatic demagnetization, First and second order Phase Transitions with examples, Clausius Clapeyron Equation and Ehrenfest equations **(7 Lectures)**

Maxwell's Thermodynamic Relations:
Derivations and applications of Maxwell's Relations, Maxwell's Relations: (1) Clausius Clapeyron equation, (2) Values of C_p-C_v, (3) Tds Equations, (4) Joule-Kelvin coefficient for Ideal and Van der Waal Gases, (5) Energy equations, (6) Change of Temperature during Adiabatic Process. **(7 Lectures)**

UNIT 2

Kinetic Theory of Gases

Distribution of Velocities: Maxwell-Boltzmann Law of Distribution of Velocities in an Ideal Gas and its Experimental Verification. Doppler Broadening of Spectral Lines and Stern's Experiment. Mean, RMS and Most Probable Speeds. Degrees of Freedom. Law of Equipartition of Energy (No proof required). Specific heats of Gases. **(7 Lectures)**

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

Real Gases: Behavior of Real Gases: Deviations from the Ideal Gas Equation. The Virial Equation.

Andrew's Experiments on CO_2 Gas. Critical Constants. Continuity of Liquid and Gaseous State. Vapour and Gas. Boyle Temperature. Van der Waal's Equation of State for Real Gases. Values of Critical Constants. Law of Corresponding States. Comparison with Experimental Curves. p-V Diagrams. Joule's Experiment. Free Adiabatic Expansion of a Perfect Gas. Joule-Thomson Porous Plug Experiment. Joule-Thomson Effect for Real and Van der Waal Gases. Temperature of Inversion. Joule-Thomson Cooling. **(10 Lectures)**

Reference Books:

- Heat and Thermodynamics, M.W. Zemansky, Richard Dittman, 1981, McGraw-Hill.
- A Treatise on Heat, Meghnad Saha, and B. N. Srivastava, 1958, IndianPress
- Thermal Physics, S. Garg, R. Bansal and Ghosh, 2nd Edition, 1993, TataMcGraw-Hill
- Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer.
- Thermodynamics, Kinetic Theory & Statistical Thermodynamics, Sears & Salinger. 1988, Narosa.
- Concepts in Thermal Physics, S.J. Blundell and K.M. Blundell, 2nd Ed., 2012, Oxford University Press

PRACTICAL Thermal Physics (Credit:01, 30 hours)

Every student must perform at least 04 experiments

1. To determine Mechanical Equivalent of Heat, J, by Callender and Barne's constant flow method.
2. To determine the Coefficient of Thermal Conductivity of Cu by Searle's Apparatus.
3. To determine the Coefficient of Thermal Conductivity of Cu by Angstrom's Method.
4. To determine the Coefficient of Thermal Conductivity of a bad conductor by Lee and Charlton's disc method.
5. To determine the Temperature coefficient of Resistance by Platinum Resistance Thermometer (PRT).
6. To study the variation of Thermo-Emf of a Thermocouple with Difference of Temperature of its Two Junctions.
7. To calibrate a thermocouple to measure temperature in a specified Range using Null Method, (2) Direct measurement using Op-Amp difference amplifier and to determine Neutral Temperature.

Reference Books

- Advanced Practical Physics for students, B. L. Flint and H.T. Worsnop, 1971, Asia Publishing House
- A Text Book of Practical Physics, I. Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal
- Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
- A Laboratory Manual of Physics for undergraduate classes, D. P. Khandelwal,1985, VaniPub.

PHC203: ANALOG SYSTEMS AND APPLICATIONS

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

Total Hours: Theory: 45, Practical: 30

L	T	P	Cr
3	0	1	4

Course Objectives:

1. To understand the concepts of P and N type semiconductors, conductivity of PN junction barriers and their fabrication.
2. To learn the applications of PN junction diodes in rectifiers, LED's, solar cells,Zener diode and voltage regulators.
3. To understand how unipolar junctions are different from bipolar junctions and learning the concept of n-p-n and p-n-p transistors.
4. To understand the concept of amplifiers and feedback amplifiers by using transistors.
5. To learn about oscillators, operational amplifiers and their applications.

Course Outcomes:

At the end of the course the student is expected to versed with the following:

1. Understand the n- and p- type semiconductors, mobility, drift velocity, fabrication of P-Njunctions; forward and reverse biased junctions, unipolar junctions, Zener diode.
2. Application of PN junctions in LED's, photodetectors, solarcells, rectifiers and voltage regulators.
3. Bipolar npn and pnp junctions, transistors.
4. Hybrid parameters.
5. Biasing and equivalent circuits, coupled amplifiers and feedback in amplifiers and oscillators
6. Understand the operational amplifies and their applications as adder, differentiator, integratoretc.
7. To apply the concepts of theory in performing the experiments in the laboratory related to PNjunction, transistors, Zener Diode and operational amplifiers.

Course Content:

UNIT 1

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. Static and Dynamic Resistance. Current Flow Mechanism in Forward and Reverse Biased Diode. **(8 Lectures)**

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, (2) Zener Diode and Voltage Regulation. Principle and structure of (1) LEDs, (2) Photodiode, (3) Solar Cell. **(6 lectures)**

UNIT 2

Bipolar Junction transistors: n-p-n and p-n-p Transistors. Characteristics of CB, CE and CC Configurations. Current gains α and β Relations between α and β. Load Line analysis of Transistors. DC Load line and Q-point. Physical Mechanism of Current Flow. Active, Cutoff and Saturation Regions. **(6 lectures)**

UNIT 3

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. **(10 lectures)**

Feedback in Amplifiers: Effects of Positive and Negative Feedback on InputImpedance, Output Impedance, Gain, Stability, Distortion and Noise. **(4 lectures)**

UNIT 4

Sinusoidal Oscillators: Barkhausen's Criterion for self-sustained oscillations. RC Phaseshift oscillator, determination of Frequency. Hartley & Colpitts oscillators. **(5 lectures)**

UNIT 5

Operational Amplifiers (Black Box approach): Characteristics of an Ideal and Practical Op-Amp. (IC 741) Open-loop and Closed-loop Gain. **Applications of Op-Amps:** (1) Inverting and non-inverting amplifiers, (2) Adder, (3) Subtractor, (4) Differentiator **(6 lectures)**

Reference Books:

- Integrated Electronics, J. Millman and C.C. Halkias, 1991, Tata Mc-GrawHill.
- Electronics: Fundamentals and Applications, J.D. Ryder, 2004, PrenticeHall.
- Solid State Electronic Devices, B.G.Streetman & S.K.Banerjee, 6th Edn.,2009, PHI Learning.
- Electronic Devices & circuits, S.Salivahanan & N.S.Kumar, 3rd Ed., 2012, Tata Mc-GrawHill.
- OP-Amps and Linear Integrated Circuit, R. A. Gayakwad, 4th edition, 2000, Prentice Hall.
- Electronic circuits: Handbook of design & applications, U.Tietze, C.Schenk,2008, Springer.
- Semiconductor Devices: Physics and Technology, S.M. Sze, 2nd Ed., 2002, WileyIndia/Electronic Devices, 7/e Thomas L. Floyd, 2008, Pearson India

PRACTICAL Analog System and Applications (Credit:01, 30 hours)

Every student must perform at least 05 experiments

1. To study V-I characteristics of PN junction diode, and Light emitting diode.
2. To study the V-I characteristics of a Zener diode and its use as voltage regulator.
3. Study of V-I & power curves of solar cells, and find maximum power point &efficiency.
4. To study the characteristics of a Bipolar Junction Transistor in CE configuration.
5. To study the various biasing configurations of BJT for normal class A operation.
6. To design a CE transistor amplifier of a given gain (mid-gain) using voltage divider bias.
7. To study the frequency response of voltage, gain of a RC-coupled transistor
8. To design a Wien bridge oscillator for given frequency using an op-amp.
9. To design a phase shift oscillator of given specifications using BJT.
10. To study the Colpitts's oscillator.
11. To design a digital to analog converter (DAC) of given specifications.
12. To study the analog to digital convertor (ADC) IC.
13. To design an inverting amplifier using Op-amp (741, 351) for dc voltage of given gain
14. To design inverting amplifier using Op-amp (741, 351) and study its frequency response
15. To design non-inverting amplifier using Op-amp (741, 351) & study its frequency response
16. To study the zero-crossing detector and comparator
17. To add two dc voltages using Op-amp in inverting and non-inverting mode
18. To design a precision Differential amplifier of given I/O specification usingOp-amp.
19. To investigate the use of an op-amp as an Integrator.
20. To investigate the use of an op-amp as a Differentiator.

Reference Books:

- Basic Electronics: A text lab manual, P.B. Zbar, A.P. Malvino, M.A. Miller, 1994,Mc-Graw Hill.
- OP-Amps and Linear Integrated Circuit, R. A. Gayakwad, 4^{th} edition, 2000, Prentice Hall.
- Electronic Principle, Albert Malvino, 2008, Tata Mc-GrawHill.
- Electronic Devices & circuit Theory, R.L. Boylestad & L.D. Nashelsky, 2009,Pearson

SEMESTER IV

PHC251: MATHEMATICAL PHYSICS III

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

Total Hours: Theory: 45, Practical: 30

L	T	P	Cr
3	0	1	4

Course Objectives:

1. The emphasis of the course is on applications in solving problems of interest to physicists.
2. The purpose of the course is to introduce students the method of mathematical physics and to develop required mathematical skill to solve the problems.
3. To impart knowledge about various mathematical tools employed to study physics problem.

Course Outcomes:

Upon successful completion of this course, it is intended that a student will be able to:

1. Demonstrate competence with the basic ideas of linear algebra including concepts of linear systems.
2. Use the method of Laplace transforms to solve initial-value problems for linear differential equations with coefficient.
3. Learn about the Fourier transform, the inverse Fourier transform, their properties and their applications in physical problems. They are also expected to learn the Laplace transform, the inverse Laplace transforms, their properties and their applications in solving physical problems.
4. In the laboratory course, the students should apply their C++/Scilab programming language to solve the following problems: (i) Solution first- and second- order ordinary differential equations with appropriate boundary conditions, (ii) Evaluation of the Gaussian integrals, Evaluation of the Fourier coefficients of a given periodic function

Course Content

UNIT 1

Frobenius Method and Special Functions: Singular Points of Second Order Linear Differential Equations and their importance. Frobenius method and its applications to differential equations. Legendre, Bessel, Hermite and Laguerre Differential Equations. Properties of Legendre Polynomials: Rodrigues Formula, Generating Function, Orthogonality. Simple recurrence relations. Expansion of function in a series of Legendre Polynomials. Bessel Functions of the First Kind: Generating Function, simple recurrence relations. Zeros of Bessel Functions and Orthogonality. (**23 Lectures**)

UNIT 2

Fourier Transforms: Fourier Integral theorem. Fourier Transform. Examples. Fourier transform of trigonometric, Gaussian, finite wave train & other functions. Representation of Dirac delta function as a Fourier Integral. Fourier transform of derivatives, Inverse Fourier transform, Convolution theorem. Properties of Fourier transforms (translation, change of scale, complex conjugation, etc.). Three dimensional Fourier transforms with examples. Application of Fourier Transforms to differential equations: One dimensional Wave and Diffusion/Heat Flow Equations. (**11 Lectures**)

UNIT 3

Laplace Transforms: Laplace Transform (LT) of Elementary functions. Properties of LTs: Change of Scale Theorem, Shifting Theorem. LTs of Derivatives and Integrals of Functions, Derivatives and Integrals of LTs. LT of Unit Step function, Dirac Delta function, Periodic Functions. Convolution Theorem. Inverse LT. Application of Laplace Transforms to Differential Equations: Damped Harmonic Oscillator, Simple Electrical Circuits. (**11 Lectures**)

Reference Books:

- Mathematical Methods for Physics and Engineers, K.F Riley, M.P. Hobson and S. J. Bence, 3rd ed., 2006, Cambridge University Press
- Mathematics for Physicists, P. Dennery and A. Krzywicki, 1967, Dover Publications
- Complex Variables, A. S. Fokas & M. J. Ablowitz, 8th Ed., 2011, Cambridge Univ. Press
- Complex Variables and Applications, J.W. Brown & R.V. Churchill, 7th Ed. 2003, Tata McGraw-Hill
- First course in complex analysis with applications, D.G. Zill and P.D. Shanahan, 1940, Jones & Bartlett

PRACTICAL Mathematical Physics III (Credit:01, 30 hours)

Scilab based simulations experiments based on Mathematical Physics problems like

1. Solve differential equations:

   $dy/dx = e^{-x}$ with $y = 0$ for $x = 0$

   $dy/dx + e^{-x}y = x^2$

   $d^2y/dt^2 + 2\, dy/dt = -y$

$d^2y/dt^2 + e^{-t}dy/dt = -y$

2. Calculation of error for each data point of observations recorded in experiments done in previous semesters (choose any two).
3. Evaluate the Calculation of least square fitting manually without giving weightage to error. Confirmation of least square fitting of data through computer program.

4. Evaluation of trigonometric functions e.g. *sin θ,* Given Bessel's functionat N points find its value at an intermediate point. Complex analysis: Integrate $1/(x^2+2)$ numerically and check with computer integration.
5. Integral transform: FFT of e^{-x^2}

Reference Books:

- Mathematics for Physicists, P. Dennery and A. Krzywicki, 1967, DoverPublications.
- Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific and Engineering Applications: A. Vande Wouwer, P. Saucez, C. V. Fernández. 2014 Springer ISBN:978-3319067896
- Scilab by example: M. Affouf, 2012. ISBN:978-1479203444
- Scilab (A free software to Matlab): H. Ramchandran, A.S. Nair. 2011S.Chand & Company
- Scilab Image Processing: Lambert M. Surhone. 2010 Betascript Publishing

PHC252: ELEMENTS OF MODERN PHYSICS

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

Total Hours: Theory: 45, Practical: 30

L	T	P	Cr
3	0	1	4

Course Objectives:

1. To understand concepts of black body radiation and plank's law.
2. To learn Schrodinger wave equation and use it to estimate various wave parameters.
3. To Acquire knowledge in the content areas of nuclear and particle physics, focusing on concepts that are commonly used in this area
4. To understand basic lasing action, study various types of lasers

Course Outcomes:

After the successful completion of the course the student is expected to be conversant with the following:

1. Know main aspects of the inadequacies of classical mechanics and understand historical development of quantum mechanics and ability to discuss and interpret experiments that reveal the dual nature of matter.
2. Understand the theory of quantum measurements, wave packets and uncertainty principle.

   of radioactive decays like alpha, beta, gamma decay. Neutrinos and its properties and role in theory of beta decay.
3. Understand fission and fusion well as nuclear processes to produce nuclear energy in nuclear reactor and stellar energy in stars.
4. Understand various interactions of electromagnetic radiation with matter. Electron positron pair creation.

Course Content

UNIT 1

Planck's quantum, Planck's constant and light as a collection of photons; Blackbody Radiation: Quantum theory of Light; Photo-electric effect and Compton scattering. De Broglie wavelength and matter waves; Davisson-Germer experiment. Wave description of particles by wave packets. Group and Phase velocities and relation between them. Two-Slit experiment with electrons. Probability. Wave amplitude and wave functions. Atomic model bohr model and somer field model

(15 Lectures)

UNIT 2

Position measurement- gamma ray microscope thought experiment; Wave-particle duality, Heisenberg uncertainty principle (Uncertainty relations involving Canonical pair of variables): Derivation from Wave Packets impossibility of a particle following a trajectory; Estimating minimum energy of a confined particle using uncertainty principle; Energy-time uncertainty principle- application to virtual particles and range of an interaction.

(5 Lectures)

UNIT 3

Two slit interference experiment with photons, atoms and particles; linear superposition principle as a consequence; Matter waves and wave amplitude; Schrodinger equation for non-relativistic particles; Momentum and Energy operators; stationary states; physical interpretation of a wave function, probabilities and normalization; Probability and probability current densities in one dimension.

(10 Lectures)

UNIT 4

One dimensional infinitely rigid box- energy eigenvalues and eigenfunctions, normalization; Quantum dot as example; Quantum mechanical scattering and tunnelling in one dimension-across a step potential & rectangular potential barrier. **(10 Lectures)**

UNIT 5

Size and structure of atomic nucleus and its relation with atomic weight; Impossibility of an electron being in the nucleus as a consequence of the uncertainty principle. Nature of nuclear force, NZ graph, Liquid Drop model: semi-empirical mass formula and binding energy, Nuclear Shell Model and magic numbers. **(6 Lectures)**

UNIT 6

Radioactivity: stability of the nucleus; Law of radioactive decay; Mean life and half-life; Alpha decay; Beta decay- energy released, spectrum and Pauli's prediction of neutrino; Gamma ray emission, energy-momentum conservation: electron-positron pair creation by gamma photons in the vicinity of a nucleus.

(8 Lectures)

Fission and fusion- mass deficit, relativity and generation of energy; Fission - nature of fragments and emission of neutrons. Nuclear reactor: slow neutrons interacting with Uranium 235; Fusion and thermonuclear reactions driving stellar energy (brief qualitative discussions). **(3 Lectures)**

UNIT 7

Lasers: Einstein's A and B coefficients. Metastable states. Spontaneous and Stimulated emissions. Optical Pumping and Population Inversion. Three-Level and Four-Level Lasers. Ruby Laser and He-Ne Laser. **(4 Lectures)**

Reference Books:

- Concepts of Modern Physics, Arthur Beiser, 2002, McGraw-Hill.
- Introduction to Modern Physics, Rich Meyer, Kennard, Coop, 2002, Tata McGraw Hill
- Introduction to Quantum Mechanics, David J. Griffith, 2005, Pearson Education.
- Physics for scientists and Engineers with Modern Physics, Jewett and Serway, 2010, Cengage Learning.
- Quantum Mechanics: Theory & Applications, A.K.Ghatak & S.Lokanathan, 2004, Macmillan

Additional Books for Reference

- Modern Physics, J.R. Taylor, C.D. Zafiratos, M.A. Dubson, 2004, PHI Learning.
- Theory and Problems of Modern Physics, Schaum`s outline, R. Gautreau and W. Savin, 2nd Edn, Tata McGraw-Hill Publishing Co. Ltd.
- Quantum Physics, Berkeley Physics, Vol.4. E.H.Wichman, 1971, Tata McGraw-Hill Co.
- Basic ideas and concepts in Nuclear Physics, K.Heyde, 3rd Edn., Institute of Physics Pub.
- Six Ideas that Shaped Physics: Particle Behave like Waves, T.A.Moore, 2003, McGraw Hill

PRACTICAL Modern Physics (Credit:01, 30 hours)

Every student must perform at least 04 experiments

1. Measurement of Planck's constant using black body radiation and photo detector
2. Photo-electric effect: photo current versus intensity and wavelength of light; maximum energy of photo-electrons versus frequency of light
3. To determine work function of material of filament of directly heatedvacuum diode.
4. To determine the Planck's constant using LEDs of at least 4 different colours.
5. To determine the wavelength of H-alpha emission line of Hydrogen atom.
6. To determine the ionization potential of mercury.
7. To determine the absorption lines in the rotational spectrum of iodine vapour.
8. To determine the value of e/m by (a) Magnetic focusing or (b) Barmagnet.
9. To setup the Millikan oil drop apparatus and determine the charge of an electron.
10. To show the tunneling effect in tunnel diode using I-V characteristics.
11. To determine the wavelength of laser source using diffraction of single slit.
12. To determine the wavelength of laser source using diffraction of double slits.
13. To determine (1) wavelength and (2) angular spread of He-Ne laserusing plane diffraction grating

Reference Books

- Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House
- Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
- A Text Book of Practical Physics, I. Prakash & Ramakrishna, 11th Edn, 2011, KitabMahal

PHC253: DIGITAL SYSTEMS AND APPLICATIONS

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

Total Hours: Theory: 45, Practical: 30

L	T	P	Cr
3	0	1	4

Course Objectives:

1. To understand the basics of cathode ray oscilloscope along with theworking.
2. Acquainting with the integrated circuits with the basic ideas of scale of integration.
3. Explaining about the difference between analog and digital systems and introduction to the binary systems.
4. To understand the various conversions, binary function, Boolean algebra,logic gates and their applications.
5. Explaining about the arithmetic and data processing circuits.
6. Explaining the construction of adder circuits, gates and combinational circuits experimentally.

Course Outcomes:

After the successful completion of the course the student is expected to be conversant with the following:

1. Basic working of an oscilloscope including its different components and to employ the same to study different wave forms and to measure voltage, current, frequency and phase.
2. Have a better idea of different components including both active and passive componentsto gain an insight into circuits using discrete components and also to learn about integrated circuits.
3. To learn about analog systems and digital systems and their differences, fundamental logic gates, combinational as well as sequential and number systems.
4. Understand and solve Boolean functions, simplification and construction of digital circuits by employing Boolean algebra.
5. Sequential systems by choosing Flip Flop as a building bock- construct multivibrators, counters to provide a basic idea about memory including RAM, ROM and also about memory organization.
6. Experimentally, can construct the logic and combinational gates.

Course Content:

UNIT 1

Integrated Circuits (Qualitative treatment only): Active & Passive components. Discrete components. Wafer. Chip. Advantages and drawbacks of ICs. Scale of integration: SSI, MSI, LSI and VLSI (basic idea and definitions only). Classification of ICs. Examples of Linear and Digital ICs. **(3 lectures)**

UNIT 2

Digital Circuits: Difference between Analog and Digital Circuits. Binary Numbers. Decimal to Binary and Binary to Decimal Conversion. BCD, Octal and Hexadecimal numbers. AND, OR and NOT Gates (realization using Diodes and Transistor). NAND and NOR Gates as Universal Gates. XOR and XNOR Gates and application as Parity Checkers. **(6 lectures)**

Boolean algebra: De Morgan's Theorems. Boolean Laws. Simplification of Logic Circuit using Boolean Algebra. Fundamental Products. Idea of Minterms and Maxterms. Conversion of a Truth table into Equivalent Logic Circuit by (1) Sum of Products Method and (2) Karnaugh Map. **(8 lectures)**

Data processing circuits: Basic idea of Multiplexers, De-multiplexers, Decoders, Encoders. **(5 lectures)**

Arithematic Circuits: Binary Addition. Binary Subtraction using 2's Complement. Half and Full Adders. Half & Full Subtractors,4-bit binary Adder/Subtractor. **(6 lectures)**

UNIT 3

Sequential Circuits: SR, D, and JK Flip-Flops. Clocked (Level and Edge Triggered) Flip-Flops. Preset and Clear operations. Race-around conditions inJK Flip-Flop. M/S JK Flip-Flop. **(6 lectures)**

UNIT 4

Timers: IC 555: block diagram and applications: Astable multivibrator and Monostable multivibrator. **(4 lectures)**

Shift registers: Serial-in-Serial-out, Serial-in-Parallel-out, Parallel-in-Serial-outand Parallel-in-Parallel-out Shift Registers (only up to 4bits). **(3 lectures)**

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

Reference Books:

- Digital Principles and Applications, A.P. Malvino, D.P. Leach andSaha, 7th Ed., 2011, Tata McGraw
- Fundamentals of Digital Circuits, Anand Kumar, 2nd Edn, 2009, PHILearning Pvt. Ltd.
- Digital Circuits and systems, Venugopal, 2011, Tata McGraw Hill.
- Digital Systems: Principles & Applications, R.J.Tocci, N.S.Widmer,2001, PHI Learning
- Logic circuit design, Shimon P. Vingron, 2012, Springer.
- Digital Electronics, Subrata Ghoshal, 2012, Cengage Learning.

PRACTICAL Digital Systems and Applications (Credit:01, 30 hours)

Every student must perform at least 06 experiments

List of Experiments

1. To measure (a) Voltage, and (b) Time period of a periodic waveform using CRO.
2. To test a Diode and Transistor using a Multimeter.
3. To design a switch (NOT gate) using a transistor.
4. To verify and design AND, OR, NOT and XOR gates using NAND gates.
5. To design a combinational logic system for a specified Truth Table.
6. To convert a Boolean expression into logic circuit and design it using logic gateICs.
7. To minimize a given logic circuit.
8. Half Adder, Full Adder and 4-bit binary Adder.
9. Half Subtractor, Full Subtractor, Adder-Su\:"-tractor using Full Adder I.C.
10. To build Flip-Flop (RS, Clocked RS, D-type and JK) circuits using NAND gates.
11. To build JK Master-slave flip-flop using Flip-Flop ICs
12. To build a 4-bit Counter using D-type/JK Flip-Flop ICs and study timing diagram.
13. To make a 4-bit Shift Register (serial and parallel) using D-type/JK Flip-Flop ICs.
14. To design an astable multivibrator of given specifications using 555Timer.
15. To design a monostable multivibrator of given specifications using 555Timer.

Reference Books:

- Modern Digital Electronics, R.P. Jain, 4th Edition, 2010, Tata McGraw Hill.
- Basic Electronics: A text lab manual, P.B. Zbar, A.P. Malvino, M.A. Miller, 1994, Mc-Graw Hill.
- Microprocessor Architecture Programming and applications with 8085, R.S. Goankar,2002, Prentice Hall.

Semester V

PHC301: QUANTUM MECHANICS I

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

Total Hours: Theory: 45, Practical: 30

L	T	P	Cr
3	0	1	4

Course Objectives:

This course will build up basic understanding about quantum mechanics to bachelor students. The objective of the course is

1. To study the basic principles of quantum mechanics.
2. Explain the operator formulation of quantum mechanics.
3. Student will learn the concept of wave function, Schrodinger equation and their applications.
4. To study role of uncertainty in quantum physics.
5. To describe the structure of the hydrogen atom and show an understanding of quantization of angular momentum.
6. To give a broad knowledge of the most important characteristics of atoms, molecules and the interaction with electromagnetic fields.

Course Outcomes:

On successful completion of the course students will be able to understand

1. How to apply principles of quantum mechanics to calculate observables on known wavefunctions
2. How to solve time-dependent and time-independent Schrödinger equation for simplepotentials.
3. The structure and dynamics of atoms and simple molecules.
4. The interaction between atoms, molecules and electromagnetic fields.
5. Quantum mechanics formulation for Hydrogen atom

Course Content:

UNIT 1

Time dependent Schrodinger equation: Time dependent Schrodinger equation and dynamical evolution of a quantum state; Properties of Wave Function. Interpretation of Wave Function Probability and probability current densities in three dimensions; Conditions for Physical Acceptability of Wave Functions. Normalization. Linearity and Superposition Principles. Eigenvalues and Eigenfunctions. Position, momentum and Energy operators; commutator of position and momentum operators; Expectation values of position and momentum. Wave Function of a Free Particle. **(6 Lectures)**

UNIT 2

Time independent Schrodinger equation-Hamiltonian, stationary states and energy eigenvalues; expansion of an arbitrary wavefunction as a linear combination of energy eigenfunctions; General solution of the time dependent Schrodinger equation in terms of linear combinations of stationary states; Application to spread of Gaussian wave-packet for a free particle in one dimension; wave packets, Fourier transforms and momentum space wavefunction; Position-momentum uncertainty principle.

(10 Lectures)

UNIT 3

General discussion of bound states in an arbitrary potential- continuity of wave function, boundary condition and emergence of discrete energy levels; application to one-dimensional problem-square well potential; Quantum mechanics of simple harmonic oscillator-energy levels and energy eigenfunctions using Frobenius method; Hermite polynomials; ground state, zero point energy & uncertainty principle.

(11 Lectures)

UNIT 4

Quantum theory of hydrogen-like atoms: time independent Schrodinger equation in spherical polar coordinates; separation of variables for second order partial differential equation; angular momentum operator & quantum numbers; Radial wavefunctions from Frobenius method; shapes of the probability densities for ground & first excited states; Orbital angular momentum quantum numbers l and m; s, p, d,.. shells. **(10 Lectures)**

UNIT 5

Atoms in Electric & Magnetic Fields: Electron angular momentum. Space quantization. Electron Spin and Spin Angular Momentum. Larmor's Theorem. Spin Magnetic Moment. Stern-Gerlach Experiment. Zeeman Effect: Electron Magnetic Moment and Magnetic Energy, Gyromagnetic Ratio and Bohr Magneton.

(8 Lectures)

Reference Books:

- A Text book of Quantum Mechanics, P. M. Mathews and K. Venkatesan, 2nd Ed.,2010, McGrawHill
- Quantum Mechanics, Robert Eisberg and Robert Resnick, 2nd Edn., 2002, Wiley.
- Quantum Mechanics, Leonard I. Schiff, 3rd Edn. 2010, Tata McGraw Hill.
- Quantum Mechanics, G. Aruldhas, 2nd Edn. 2002, PHI Learning of India.
- Quantum Mechanics, Bruce Cameron Reed, 2008, Jones and Bartlett Learning.

- Quantum Mechanics: Foundations & Applications, Arno Bohm, 3rd Edn., 1993, Springer
- Quantum Mechanics for Scientists & Engineers, D.A.B. Miller, 2008, CambridgeUniversity Press

Additional Books for Reference:

- Quantum Mechanics, Eugen Merzbacher, 2004, John Wiley and Sons, Inc.
- Introduction to Quantum Mechanics, D.J. Griffith, 2nd Ed. 2005, Pearson Education
- Quantum Mechanics, Walter Greiner, 4th Edn., 2001, Springer

PRACTICAL Quantum Mechanics I (Credit:01, 30 hours)

Laboratory based experiments: (perform at least two)

1. Study of Electron spin resonance- determine magnetic field as a function of theresonance frequency
2. Study of Zeeman effect: with external magnetic field; Hyper fine splitting
3. To show the tunneling effect in tunnel diode using I-V characteristics.
4. Quantum efficiency of CCDs

Using C/C++/Scilab for solving the following problems based on Quantum Mechanics like

1. Solve the s-wave Schrodinger equation for the ground state and the first excited state of the hydrogen atom:

$$\frac{d^2y}{d^2x} = A(r)u(r), A(r) = \frac{2m}{\hbar^2}[V(r) - E] \; where \; V(r) = -\frac{e^2}{r}$$

Here, m is the reduced mass of the electron. Obtain the energy eigen values and plot the corresponding wave functions. Remember that the ground state energy of the hydrogen atom is ≈ -13.6 eV. Take e = 3.795 $(eVÅ)^{1/2}$, ħc = 1973 (eVÅ) and m = 0.511×10^6 eV/c^2.

Reference Books:

- Schaum's outline of Programming with C++. J.Hubbard, 2000,McGraw‐Hill Publication
- Numerical Recipes in C: The Art of Scientific Computing, W.H. Press etal., 3rdEdn., 2007,Cambridge University Press.
- An introduction to computational Physics, T.Pang, 2nd Edn.,2006, Cambridge Univ. Press
- Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific & Engineering Applications: A. Vande Wouwer, P. Saucez, C. V. Fernández.2014Springer.
- Scilab (A Free Software to Matlab): H. Ramchandran, A.S. Nair. 2011 S. Chand & Co.
- Scilab Image Processing: L.M. Surhone.2010 Betascript PublishingISBN:978-6133459274

PHC302: ELECTROMAGNETIC THEORY

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

Total Hours: Theory: 45, Tutorial: 15

L	T	P	Cr
3	1	0	4

Course Objectives:

1. To understand basic concepts about Maxwell's equations and Electromagnetic waves
2. To learn wave propagation in the ionosphere
3. To learn various concepts of polarization of light waves, their generation and detection
4. To learn concepts of wave propagation through waveguide
5. Understand the magnetic effects of electric current.
6. To learn about the unification of electric and magnetic phenomena.

Course Outcomes:

After successful completion of course, students should be able to

1. solve the problems of electrostatics and magnetism.
2. should be able to learn and use the maxwell's equations in possible applications.
3. should understand properties of radiation and its interaction with the matter and the special theoretical effects.
4. Should understand the concept of polarization of electromagnetic waves.

Course Content:

UNIT 1

Maxwell Equations: Review of Maxwell's equations. Displacement Current. Vector and Scalar Potentials. Gauge Transformations: Lorentz and Coulomb Gauge. Boundary Conditions at Interface between Different Media. Wave Equations. Plane Waves in Dielectric Media. Poynting Theorem and Poynting Vector. Electromagnetic (EM) Energy Density. Physical Concept of Electromagnetic Field Energy Density, Momentum Density and Angular Momentum Density. **(11 Lectures)**

UNIT 2

EM Wave Propagation in Unbounded Media: Plane EM waves through vacuum and isotropic dielectric medium, transverse nature of plane EM waves, refractive index and dielectric constant, wave impedance. Propagation through conducting media, relaxation time, skin depth. Wave propagation through dilute plasma, electrical conductivity of ionized gases, plasma frequency, refractive index, skin depth, application to propagation through ionosphere. **(9 Lectures)**

UNIT 3

EM Wave in Bounded Media: Boundary conditions at a plane interface between two media. Reflection & Refraction of plane waves at plane interface between two dielectric media-Laws of Reflection & Refraction. Fresnel's Formulae for perpendicular & parallel polarization cases, Brewster's law. Reflection & Transmission coefficients. Total internal reflection, evanescent waves. Metallic reflection (normal Incidence). **(9 Lectures)**

UNIT 4

Polarization of Electromagnetic Waves: Description of Linear, Circular and Elliptical Polarization. Propagation of E.M. Waves in Anisotropic Media. Symmetric Nature of Dielectric Tensor. Fresnel's Formula. Uniaxial and Biaxial Crystals. Light Propagation in Uniaxial Crystal. Double Refraction. Polarization by Double Refraction. Nicol Prism. Ordinary & extraordinary refractive indices. Production & detection of Plane, Circularly and Elliptically Polarized Light. Phase Retardation Plates: Quarter-Wave and Half-Wave Plates. Babinet Compensator and its Uses. Analysis of Polarized Light **(11 Lectures)**

Rotatory Polarization: Optical Rotation. Biot's Laws for Rotatory Polarization. Fresnel's Theory of optical rotation. Calculation of angle of rotation. Experimental verification of Fresnel's theory. Specific rotation. Laurent's half-shade polarimeter. **(5 Lectures)**

Reference Books:

- Introduction to Electrodynamics, D.J. Griffiths, 3rd Ed., 1998, BenjaminCummings.
- Elements of Electromagnetics, M.N.O. Sadiku, 2001, Oxford UniversityPress.
- Introduction to Electromagnetic Theory, T.L. Chow, 2006, Jones & BartlettLearning
- Fundamentals of Electromagnetics, M.A.W. Miah, 1982, Tata McGrawHill
- Electromagnetic field Theory, R.S. Kshetrimayun, 2012, CengageLearning
- Electromagnetic Field Theory for Engineers & Physicists, G. Lehner, 2010, Springer

Additional Books for Reference

- Electromagnetic Fields & Waves, P.Lorrain & D.Corson, 1970, W.H.Freeman & Co.

- Electromagnetics, J.A. Edminster, Schaum Series, 2006, Tata McGraw Hill.
- Electromagnetic field theory fundamentals, B. Guru and H. Hiziroglu, 2004, Cambridge University Press

Reference Books

- Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, AsiaPublishing House.
- Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4^{th} Edition,reprinted 1985, Heinemann Educational Publishers
- A Textbook of Practical Physics, I. Prakash & Ramakrishna, 11^{th} Ed., 2011, KitabMahal
- Electromagnetic Field Theory for Engineers & Physicists, G. Lehner, 2010, Springer

PHC303 NUCLEAR PHYSICS

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

Total Hours: Theory: 45, Tutorial: 15

L	T	P	Cr
3	0	1	4

Course Objectives:

1. To understand the basics of nuclear physics.
2. To provide an understanding of static properties of nuclei, nuclear decay modes, nuclear force and nuclear models.

Course Outcomes:

1. Students shall be able to learn the basics theories and phenomenon of nuclear physics and particle physics involving relativistic quantum theory, mesons and strange particles, basic quantum numbers, weak and strong interactions.
2. The students will have an understanding of the structure of the nucleus, radioactive decay, nuclear reactions and the interaction of nuclear radiation with matter.

Course Content

UNIT 1

General Properties of Nuclei: Constituents of nucleus agnd their Intrinsic properties, quantitative facts about mass, radii, charge density (matter density), binding energy, average binding energy and its variation with mass number, main features of binding energy versus mass number curve, N/A plot, angular momentum, parity, magnetic moment, electric moments, nuclear excites states. **(10 Lectures)**

UNIT 2

Nuclear Models: Liquid drop model approach, semi empirical mass formula and significance of its various terms, condition of nuclear stability, two nucleon separation energies, Fermi gas model (degenerate fermion gas, nuclear symmetry potential in Fermi gas), evidence for nuclear shell structure, nuclear magic numbers, basic assumption of shell model, concept of mean field, residual interaction, concept of nuclear force.

(12 Lectures)

UNIT 3

Radioactivity decay:(a) Alpha decay: basics of α -decay processes, theory of α -emission, Gamow factor, Geiger Nuttall law, α-decay spectroscopy. (b) β-decay: energy kinematics for β-decay, positron emission, electron capture, neutrino hypothesis. (c) Gamma decay: Gamma rays emission & kinematics, internal conversion. **(9 Lectures)**

Nuclear Reactions: Types of Reactions, Conservation Laws, kinematics of reactions, Q-value, reaction rate, reaction cross section, Concept of compound and direct Reaction, resonance reaction, Coulomb scattering (Rutherford scattering). **(8 Lectures)**

UNIT 4

Nuclear Astrophysics: Early universe, primordial nucleosynthesis (particle nuclear interactions), stellar nucleosynthesis, concept of gamow window, heavy element production: r- and s- process path.

(6 Lectures)

Reference Books:

- Introductory nuclear Physics by Kenneth S. Krane (Wiley India Pvt. Ltd., 2008).
- Concepts of nuclear physics by Bernard L. Cohen. (Tata Mcgraw Hill, 1998).
- Introduction to the physics of nuclei & particles, R.A. Dunlap. (Thomson Asia, 2004).
- Nuclear Physics, H.M. Agrawal, PHI (2006).
- Introduction to High Energy Physics, D.H. Perkins, Cambridge Univ. Press
- Quarks and Leptons, F. Halzen and A.D. Martin, Wiley India, New Delhi
- Basic ideas and concepts in Nuclear Physics - An Introductory Approach by K. Heyde (IOP- Institute of Physics Publishing, 2004).

PRACTICAL Nuclear Physics (Credit:01, 30 hours)

Laboratory based experiments

1. Plateau Characteristics of a GM counter
2. Determination of the dead time of a GM counter
3. Statistical aspects of radioactivity measurements
4. Determination of resolution of NaI (Tl) detector

Semester VI

PHC351: SOLID STATE PHYSICS

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

Total Hours: Theory: 45, Practical: 30

L	T	P	Cr
3	0	1	4

Course Objectives:

This course will build up basic understanding about solid state Physics to bachelorstudents.

The objectives of the course are:

1. To understand about the crystal structure, lattice, unit cell and miller indices.
2. To know the difference between amorphous and crystalline materials.
3. To understand about the elementary concepts of lattice vibrations and varioustheories related to that.
4. To understand about the magnetism in materials and various concepts related tothat.
5. To learn about the dielectric and ferroelectric properties in materials.
6. To understand about the concepts of band theory and basics of superconductivity.

Course Outcomes:

1. A brief idea about crystalline and amorphous substances, about lattice, unit cell, miller indices, reciprocal lattice, concept of Brillouin zones and diffraction of X- rays by crystalline materials.
2. Understanding of lattice vibrations, phonons and learning of Einstein and Debyetheory of specific heat of solids.
3. Better understanding of magnetism (dia, para, ferro) and theories related to that.
4. Secured an understanding about the dielectric and ferroelectric properties of materials.
5. Understanding above the band theory of solids and must be able to differentiate insulators, conductors and semiconductors.
6. Understand the basic idea about superconductors and their classifications.
7. To carry out experiments based on the theory that they have learned to measure the magnetic susceptibility, dielectric constant, trace hysteresis loop. They will also employ to four probe methods to measure electrical conductivity and the hallset up to determine the hall coefficient of a semiconductor.

Course Content:

UNIT 1

Crystal Structure: Solids: Amorphous and Crystalline Materials. Lattice Translation Vectors. Lattice with a Basis – Central and Non-Central Elements. Unit Cell. Miller Indices. Reciprocal Lattice. Types of Lattices. Brillouin Zones. Diffraction of X-rays by Crystals. Bragg's Law. Atomic and Geometrical Factor.

(9 lectures)

UNIT 2

Elementary Lattice Dynamics: Lattice Vibrations and Phonons: Linear Monoatomic and Diatomic Chains. Acoustical and Optical Phonons. Qualitative Description of the Phonon Spectrum in Solids. Dulong and Petit's Law, Einstein and Debye theories of specific heat of solids. T^3 law **(9 lectures)**

UNIT 3

Electrical Conductivity, Drude-Lorentz Theory of Electrical Conductivity, Sommerfield theory of electrical conductivity, Mathiessen's Rule, Hall Effect. Measurement of conductivity (04 probe method) & Hall coefficient. **(5 lectures)**

UNIT 4

Magnetic Properties of Matter: Dia-, Para-, Ferri- and Ferromagnetic Materials. Classical Langevin Theory of dia- and Paramagnetic Domains. Curie's law, Weiss's Theory of Ferromagnetism and Ferromagnetic Domains. Discussion of B-H Curve. Hysteresis and Energy Loss,

(8 lectures)

UNIT 5

Dielectric Properties of Materials: Polarization. Local Electric Field at an Atom. Depolarization Field. Electric Susceptibility. Polarizability. Clausius Mosotti Equation. Classical Theory of Electric Polarizability, Normal and anomalous dispersion, complex dielectric constant **(4 lectures)**

UNIT 6

Ferroelectric Properties of Materials: Structural phase transition, Classification of crystals, Piezoelectric effect, Pyroelectric effect, Ferroelectric effect, Curie-Weiss Law, Ferroelectric domains, PE hysteresis loop. **(5 lectures)**

UNIT 7

Superconductivity: Experimental Results. Critical Temperature. Critical magnetic field.Meissner effect. Type I and type II Superconductors, London's Equation and Penetration depth. Isotope effect. Idea of BCS theory (No derivation). **(5 lectures)**

Reference Books:

- Introduction to Solid State Physics, Charles Kittel, 8th Edition, 2004, Wiley IndiaPvt. Ltd.
- Elements of Solid State Physics, J.P. Srivastava, 2nd Edition, 2006, Prentice-Hall ofIndia.
- Introduction to Solids, Leonid V. Azaroff, 2004, Tata Mc-Graw HillSolid State Physics, N.W. Ashcroft and N.D. Mermin, 1976, Cengage Learning.
- Solid-state Physics, H. Ibach and H. Luth, 2009, Springer.
- Elementary Solid State Physics, 1/e M. Ali Omar, 1999, Pearson India.
- Solid State Physics, M.A. Wahab, 2011, Narosa Publications.

PRACTICAL Solid State Physics (Credit:01, 30 hours)

Every student must perform at least 05 experiments

1. Measurement of susceptibility of paramagnetic solution (Quinck`s Tube Method)
2. To measure the Magnetic susceptibility of Solids.
3. To determine the Coupling Coefficient of a Piezoelectric crystal.
4. To measure the Dielectric Constant of a dielectric Materials with frequency
5. To determine the complex dielectric constant and plasma frequency of metal using Surface Plasmon resonance (SPR)
6. To determine the refractive index of a dielectric layer using SPR
7. To study the PE Hysteresis loop of a Ferroelectric Crystal.
8. To draw the BH curve of Fe using Solenoid & determine energy loss from Hysteresis.
9. To measure the resistivity of a semiconductor (Ge) with temperature by four-probe method (room temperature to 150 ^{o}C) and to determine its band gap.
10. To determine the Hall coefficient of a semiconductor sample.

Reference Books

- Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, AsiaPublishing House.
- Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition,reprinted 1985, Heinemann Educational Publishers.
- A Text Book of Practical Physics, I. Prakash & Ramakrishna, 11th Ed., 2011, Kitab Mahal
- Elements of Solid State Physics, J.P. Srivastava, 2nd Ed., 2006, Prentice-Hall ofIndia.

PHC352: STATISTICAL MECHANICS

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

Total Hours: Theory: 45, Practical: 30

L	T	P	Cr
3	0	1	4

Course Objectives:

The objective of this course is to learn the basic concepts and definition of

1. Physical quantities in classical statistics and classical distribution law.
2. To learn the application of classical statistics to theory of radiation.
3. To comprehend the failure of classical statistics and need for quantum statistics.

Course Outcomes:

After completion of the course, student shall be able to

1. Basics of thermodynamics and various mathematics tools.
2. A treatise to the derivation of such phenomenon is presented based on statistical mechanical analysis employing classical and quantum mechanics-based approaches.

Course Content:

UNIT 1

Classical Statistics: Macrostate & Microstate, Elementary Concept of Ensemble, Entropy and Thermodynamic Probability, Maxwell-Boltzmann Distribution Law, Partition Function, Thermodynamic Functions of an Ideal Gas, Classical Entropy Expression, Gibbs Paradox, Sackur Tetrode equation, Thermodynamic Functions of a Two-Energy Levels System, Negative Temperature.

(9 Lectures)

UNIT 2

Classical 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-Jean's Law. Ultraviolet Catastrophe.

(9 Lectures)

UNIT 3

Quantum Theory of Radiation: Spectral Distribution of Black Body Radiation. Planck's Quantum Postulates. Planck's Law of Blackbody Radiation: Experimental Verification. Deduction of (1) Wien's Distribution Law, (2) Rayleigh-Jeans Law, (3) Stefan-Boltzmann Law, (4) Wien's Displacement law from Planck's law. **(9 Lectures)**

UNIT 4

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

UNIT 5

Fermi-Dirac Statistics: Fermi-Dirac Distribution Law, Thermodynamic functions of a Completely and strongly Degenerate Fermi Gas, Fermi Energy, Electron gas in a Metal, Specific Heat of Metals, Relativistic Fermi gas, White Dwarf Stars, Chandrasekhar Mass Limit. **(9 Lectures)**

Reference Books:

- Statistical Mechanics, R.K. Pathria, Butterworth Heinemann: 2nd Ed., 1996, Oxford University Press.
- Statistical Physics, Berkeley Physics Course, F. Reif, 2008, TataMcGraw-Hill
- Statistical and Thermal Physics, S. Lokanathan and R.S. Gambhir. 1991, Prentice Hall Thermodynamics, Kinetic Theory and Statistical Thermodynamics, Francis W. Sears and Gerhard L. Salinger, 1986, Narosa.
- Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich,2009, Springer
- An Introduction to Statistical Mechanics & Thermodynamics, R.H. Swendsen, 2012, Oxford Univ. Press

PRACTICAL Statistical Mechanics (Credit:01, 30 hours)

Use C/C^{++}/Scilab for solving the problems based on Statistical Mechanics like

1. Plot Planck's law for Black Body radiation and compare it with Wein's Law and Raleigh-Jeans Law at high temperature (room temperature) and low temperature.
2. Plot Specific Heat of Solids by comparing (a) Dulong-Petit law, (b) Einstein distribution function, (c) Debye distribution function for high temperature (room temperature) and low temperature and compare them for these two cases

3. Plot Maxwell-Boltzmann distribution function versus temperature.
4. Plot Fermi-Dirac distribution function versus temperature.
5. Plot Bose-Einstein distribution function versus temperature.

Reference Books:

- Elementary Numerical Analysis, K.E. Atkinson, 3 rd Edn. 2007, Wiley India Edition
- Statistical Mechanics, R.K. Pathria, Butterworth Heinemann: 2nd Ed., 1996, Oxford UniversityPress.
- Thermodynamics, Kinetic Theory and Statistical Thermodynamics, Francis W. Sears and Gerhard L. Salinger, 1986, Narosa.
- Modern Thermodynamics with Statistical Mechanics, Carl S. Helrich, 2009, Springer.Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific and Engineering Applications: A. Vande Wouwer, P. Saucez, C. V. Fernández. 2014 Springer ISBN:978-3319067896
- Scilab by example: M. Affouf, 2012. ISBN:978-1479203444
- Scilab Image Processing: L. M. Surhone. 2010, Betascript Pub., ISBN: 978- 6133459274

PHC353: COMPUTATIONAL PHYSICS

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

Total Hours: Theory: 45, Practical: 30

L	T	P	Cr
3	0	1	4

Course Objectives:

This hand on course provides

1. An introduction to computational methods in solving problems in physics.
2. programming tacts, numerical methods and their implementation.
3. techniques usedto solve physics problems numerically.

Course Outcomes:

Students shall be able

1. to learn a computer programming language and basics of computational methods in interpolation, root finding, differentiation, integration, eigenvalue determination, FFT, solution of differential equation etc.
2. Identify programming methods and describe the extent and limitations of computational methods in physics.
3. Formulate and computationally solve a selection of problems in physics.

Course Content

UNIT 1

Introduction to programming language: Overview of computer organization, hardware, software, scientific programming in FORTRAN, PYTHON or C, C++.

UNIT 2

Numerical techniques: Interpolation, extrapolation, regression, numerical integration, quadrature, random number generation, linear algebra and matrix manipulations, inversion, diagonalization, eigenvectors and eigenvalues, integration of initial-value problems, Euler, Runge-Kutta, and Verlet schemes, root searching, optimization, fast Fourier transforms.

References:

- V. Rajaraman, Computer Programming in Fortran 77.
- W.H. Press, B.P. Flannery, S.A. Teukolsky and W.T. Vetterling, Numerical Recipes in FORTRAN 77: The Art of Scientific Computing. (Similar volumes in C, C++.)
- H.M. Antia, Numerical Methods for Scientists and Engineers.
- D.W. Heermann, Computer Simulation Methods in Theoretical Physics.
- H. Gould and J. Tobochnik, An Introduction to Computer Simulation Methods.
- J.M. Thijssen, Computational Physics

SEMESTER VII

PHC401: CLASSICAL MECHANICS

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

Total Hours: Theory: 45, Tutorial: 15

L	T	P	Cr
3	1	0	4

Course Objectives:

The course aims

1. To develop the idea of theoretical understanding of motion of a group of particles involving a wide range of length and energy scales.
2. To develop an understanding of Lagrangian and Hamiltonian formulation which allow for simplified treatments of many complex problems in classical mechanics and provides the foundation for the modern understanding of dynamics.

Course Outcomes:

After successful completion of the course;

1. Students will be able to try finding solution of a time evolution of state of a system employing Lagrangian and Hamiltonian approaches.
2. The students will be able to apply the Variational principles to real physical problems.
3. Students will be able to understand the two-body central force problem and small oscillations problem in detail considering the direct applications in many systems at atomic to stellar scale.

Course Content:

UNIT 1

Lagrangian and Hamiltonian Formulations of Mechanics: Calculus of variations, Hamilton's principle of least action, Lagrange's equations of motion, conservation laws,systems with a single degree of freedom, rigid body dynamics, symmetrical top, Hamilton's equations of motion, phase plots, fixed points and their stabilities.

UNIT 2

Two-Body Central Force Problem: Equation of motion and first integrals, classification of orbits, Kepler problem, scattering in central force field.

UNIT 3

Small Oscillations: Linearization of equations of motion, free vibrations and normal coordinates, forced oscillations.

UNIT 4

Special Theory of Relativity: Lorentz transformation, relativistic kinematics and dynamics, $E=mc^2$.

UNIT 5

Hamiltonian Mechanics and Chaos: Canonical transformations, Poisson brackets, Hamilton-Jacobi theory, action-angle variables, perturbation theory, integrable systems, introduction to chaotic dynamics.

Reference Books:

- H. Goldstein, Classical Mechanics.
- L.D. Landau and E.M. Lifshitz, Mechanics.
- I.C. Percival and D. Richards, Introduction to Dynamics.
- J.V. Jose and E.J. Saletan, Classical Dynamics: A Contemporary Approach.
- E.T. Whittaker, A Treatise on the Analytical Dynamics of Particles and Rigid Bodies.
- N.C. Rana and P.S. Joag, Classical Mechanics.
- Classical Mechanics, H.M. Agrawal, New age international, 2019.

SEMESTER VIII

PHC451: QUANTUM MECHANICS II

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

Total Hours: Theory: 45, Tutorial: 15

L	T	P	Cr
3	1	0	4

Course Objectives:

1. To grow the understanding of Quantum mechanics for more application point of viewon the foundations of basics learned in the previous quantum mechanics' course.
2. To understand the concepts of the time-dependent perturbation theory and their applications to physical situations.
3. To understand the basics of scattering theory.

Course Outcomes:

Students would achieve the ability to:

1. Find the connection between statistics and thermodynamics.
2. Differentiate between different ensemble theories used to explain the behavior of thesystems.
3. Differentiate between classical statistics and quantum statistics.
4. Explain the statistical behavior of ideal Bose and Fermi systems.
5. Apply the statistical distribution in real life problems and understand their problems.

Course Content:

UNIT 1

Time independent Perturbation Theory: Time independent perturbation theory for non-degenerate and degenerate systems upto second order perturbation. Application to a harmonic oscillator, first order Stark effect in hydrogen atom, Zeeman effect with electron spin.

Variation principle, application to ground state of helium atom, electron interaction energy and extension of variational principle to excited states. WKB approximation: energy levels of a potential well, quantization rules.

UNIT 2

Time Dependent Perturbation Theory: Time dependent perturbation theory, constant perturbation, Fermi Golden rule, coulomb excitation, sudden and adiabatic approximation, Harmonic perturbation, radiative transition in atoms, Semi-classical treatment of radiation, Einstein's A and B coefficients and spontaneous emission of radiation.

UNIT 3

Scattering Theory: General considerations; kinematics, wave mechanical picture, scattering amplitude, differential and total cross-section. Green's function for scattering. Partial wave analysis: asymptotic behavior of partial waves, phase shifts, scattering amplitude in terms of phase shifts, cross-sections, optical theorem, phase shifts and its relation to potential, application to low energy scattering, exactly soluble problems; square-well, hard sphere, coulomb potential, Born approximation; its validity, Born series.

UNIT 4

Relativistic Wave Equations: Generalization of the Schrödinger equation; Klein-Gordon equation and its drawbacks, plane wave solutions, charge and current densities, interaction with electromagnetic fields, Dirac's equation for a free particle, relativistic Hamiltonian, probability density, expectation values, Dirac gamma matrices, and their properties, non- relativistic limit of Dirac equation, plane wave solution, energy spectrum of hydrogen atom, electron spin and magnetic moment, Non conservation of orbital angular momentum and ideaof spin, interpretation of negative energy and theory of positron.

Reference Books:

- D. J. Griffiths, Introduction to Quantum Mechanics (Pearson).
- J. J. Sakurai, Advanced Quantum Mechanics (Wesley).
- N. Zettili, Quantum Mechanics Concepts and Applications (Wiley)
- A. K. Ghatakh and S. Lokanathan, Quantum Mechanics 3rded. (MacMillan).
- L. I. Schiff, Quantum Mechanics (McGraw Hill).
- C. Cohen-Tannoudji, Quantum Mechanics (Volume I and II).

DISCIPLINE SECIFIC ELECTIVES

PHE101: ADVANCED MATHEMATICAL PHYSICS

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

Total Hours: Theory: 45, Tutorial: 15

L	T	P	Cr
3	1	0	4

Course Objectives:

The purpose of the course is to introduce students to the method of Mathematical Physics. The student will:

1. Understand about linear algebra and various properties of vector spaces.
2. Understand about matrices and their properties, different types of matrices viz., Hermitian, skew Hermitian, orthogonal and unitary matrices.
3. Understand the basics of variational principle and its applications.

Course Outcomes:

After successful completion of the course, the students will:

1. Learn the basic properties of the linear vector space such as linear dependence and independence of vectors, change of basis, isomorphism and homomorphism, linear transformations and their representation by matrices.
2. Learn the basic properties of matrices, different types of matrices viz., Hermitian, skew Hermitian, orthogonal and unitary matrices.
3. Students will learn to find eigen values and eigen vectors.
4. Learn the hypothesis of the variational principle and its application to the problems in physics and geometry.

Course Content:

UNIT 1

Linear Algebra: Vector Spaces: Vector Spaces over Fields of Real and Complex numbers. Examples. Vector space of functions. Linear independence of vectors. Basis and dimension of a vector space. Change of basis. Subspace. Isomorphisms. Inner product and Norm. Inner product of functions: the weight function. Triangle and Cauchy Schwartz Inequalities. Orthonormal bases. Sine and cosine functions in a Fourier series as an orthonormal basis. Gram Schmidt orthogonalisation.

(13 lectures)

UNIT 2

Linear Transformations: Introduction. Identity and inverse. Singular and non-singular transformations. Representation of linear transformations by matrices. Similarity transformation. Linear operators. Differential operators as linear operators on vector space of functions. Commutator of operators. Orthogonal and unitary operators and their matrix representations. Adjoint of a linear operator. Hermitian operators and their matrix representation. Hermitian differential operators and boundary conditions. Examples. Eigenvalues and eigenvectors of linear operators. Properties of eigenvalues and eigenvectors of Hermitian and unitary operators. Functions of Hermitian operators/ matrices. **(19 lectures)**

UNIT 3

Calculus of Variations

Variational Principle: Euler’s Equation. Application to Simple Problems (shape of a soap film, Fermat's Principle, etc.). Several Dependent Variables and Euler's Equations. Example: Hamilton's Principle and the Euler-Lagrange equations of motion. Geodesics: geodesic equation as a set of Euler's equations.

Constrained Variations: Variations with constraints. Applications: motion of a simple pendulum, particle constrained to move on a hoop**. (13 lectures)**

Reference Books:

- Mathematical Tools for Physics, James Nearing, 2010, Dover Publications
- Mathematical Methods for Physicists, G.B. Arfken, H.J. Weber, and F.E. Harris, 1970,Elsevier.
- Introduction to Matrices and Linear Transformations, D.T. Finkbeiner, 1978, Dover Pub.
- Linear Algebra, W. Cheney, E.W. Cheney & D.R. Kincaid, 2012, Jones & Bartlett Learning
- Mathematics for Physicists, Susan M. Lea, 2004, Thomson Brooks/Cole
- Mathematical Methods for Physicis & Engineers, K.F. Riley, M.P. Hobson, S.J. Bence, 3rd Ed., 2006, Cambridge University Press

PHE102: BIOPHYSICS I

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

Total Hours: Theory: 45, Tutorial: 15

L	T	P	Cr
3	1	0	4

Course Objectives:

This course will develop Physics students to

1. Deal with principles of physics and related sciences to understand the various phenomenon of living cells and organism.
2. Relates the concepts in routine observations, functions of chloroplast and mitochondria, body temperature, heat transfer thermodynamics of living organism and its regulation.
3. Recall and describe the structure of cell membrane, membrane transport systems and membrane potential.
4. Solve qualitative and quantitative problems, using appropriate statistical mechanics.

Course Outcomes:

After successful completion of the course, the students will be able to understand about

1. Biological structure and molecular forces.
2. Important role of heat transfer, thermodynamics, statistical mechanics and diffusionin biological domain.
3. Bioenergetics and light absorption of biomolecules.
4. Biophysical phenomenon such as diffusion, establishment of membrane potential, bioimpedance, and the electrical response of cells and organelles to external fields.

Course Content:

UNIT 1

Buiding Blocks & Structure of Living State: Atoms and ions, molecules essential for life, what is life. **Living state interactions:** Forces and molecular bonds, electric & thermal interactions, electric dipoles, casimir interactions, domains of physics in biology.

Heat Transfer in biomaterials: Heat Transfer Mechanism, The Heat equation, Joule heating of tissue. **(18 lectures)**

UNIT 2

Living State Thermodynamics: Thermodynamic equilibrium, first law of thermodynamics and conservation of energy. Entropy and second law of thermodynamics, Physics of many particle systems, Two state systems, continuous energy distribution, Composite systems, Casimir contribution of free energy, Protein folding and unfolding. **(19 lectures)**

UNIT 3

Open systems and chemical thermodynamics: Enthalpy, Gibbs Free Energy and chemical potential, activation energy and rate constants, enzymatic reactions, ATP hydrolysis & synthesis, Entropy of mixing, The grand canonical ensemble, Hemoglobin. **(8 lectures)**

Reference Books:

- Introductory Biophysics, J. Claycomb, JQP Tran, Jones & Bartelett Publishers
- Aspects of Biophysics, Hughe S W, John Willy and Sons.
- Essentials of Biophysics by P Narayanan, New Age International

PHE103: NANO MATERIALS AND APPLICATIONS

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

Total Hours: Theory: 45, Practical: 30

L	T	P	Cr
3	0	1	4

Course Objectives:

This course will develop basic understanding of the nano systems and their applications. The objectives of the course are:

1. To acquaint the students with nanoscale systems, 1D, 2D and 3D systems.
2. To understand about the synthesis of nanostructure materials by variousdeposition processes.
3. To familiarize about various characterization techniques such as XRD and electron microscopy.
4. To understand about various optical properties in nanoscale systems.
5. To learn about electron transport in nanomaterials.

Course Outcomes:

At the end of the course the student is expected understand the following:

1. In the Nano systems and its implications in modifying the properties of materials at the nanoscale.509
2. Concept of Quantum confinement, 3D, 2D, 1D and 0D nanostructure with examples.
3. Different synthesis techniques including top down and bottom-up approaches.
4. Characterization of nanostructured materials using X-ray diffraction, electron microscopy, Atomic Force Microscopy and Scanning Tunneling Microscopy.
5. Optical properties of nanostructured materials, modification of band gap, excitonicconfinement.

Course Content:

UNIT 1

NANOSCALE SYSTEMS: Length scales in physics, Nanostructures: 1D, 2D and 3D nanostructures (nanodots, thin films, nanowires, nanorods)**,** Band structure and density of states of materials at nanoscale, Size Effects in nano systems, Quantum confinement: Applications of Schrodinger equation- Infinite potential well, potential step, potential box, quantum confinement of carriers in 3D, 2D, 1D nanostructures and its consequences. **(10 Lectures)**

UNIT 2

SYNTHESIS OF NANOSTRUCTURE MATERIALS: Top down and Bottom-up approach, Photolithography. Ball milling. Gas phase condensation. Vacuum deposition. Physical vapor deposition (PVD): Thermal evaporation, E-beam evaporation, Pulsed Laser deposition. Chemical vapor deposition (CVD). Sol-Gel. Electro deposition. Spray pyrolysis. Hydrothermal synthesis. Preparation through colloidal methods. MBE growth of quantum dots. **(10 Lectures)**

UNIT 3

CHARACTERIZATION: X-Ray Diffraction. Optical Microscopy. Scanning Electron Microscopy. Transmission Electron Microscopy. Atomic Force Microscopy. Scanning Tunneling Microscopy. **(8 Lectures)**

UNIT 4

OPTICAL PROPERTIES: Coulomb interaction in nanostructures. Concept of dielectric constant for nanostructures. Quasi-particles and excitons. Excitons in direct and indirect band gap semiconductor nanocrystals. Quantitative treatment of quasi-particles and excitons, charging effects. Radiative processes: General formalization-absorption, emission and luminescence. Optical properties of heterostrctures and nanostructures. **(11 Lectures)**

UNIT 5

ELECTRON TRANSPORT: Carrier transport in nanostructures. Coulomb blockade effect, thermionic emission, tunneling and hoping conductivity. Defects and impurities: Deep level and surface defects. **(6 Lectures)**

Reference books:

- C.P. Poole, Jr. Frank J. Owens, Introduction to Nanotechnology (Wiley India Pvt. Ltd.).
- S.K. Kulkarni, Nanotechnology: Principles & Practices (Capital Publishing Company).
- K.K. Chattopadhyay and A. N. Banerjee, Introduction to Nanoscience andTechnology (PHI Learning Private Limited).
- Richard Booker, Earl Boysen, Nanotechnology (John Wiley and Sons).
- M. Hosokawa, K. Nogi, M. Naita, T. Yokoyama, Nanoparticle TechnologyHandbook (Elsevier, 2007).
- Bharat Bhushan, Springer Handbook of Nanotechnology (Springer-Verlag, Berlin,2004).

PRACTICAL Nano Materials and Applications (Credit:01, 30 hours)

List of Experiments:

1. Synthesis of metal nanoparticles by chemical route.
2. Synthesis of semiconductor nanoparticles.
3. Surface Plasmon study of metal nanoparticles by UV-Visible spectrophotometer.
4. XRD pattern of nanomaterials and estimation of particle size.
5. To study the effect of size on color of nanomaterials.
6. To prepare composite of CNTs with other materials.
7. Growth of quantum dots by thermal evaporation.
8. Prepare a disc of ceramic of a compound using ball milling, pressing and sintering, and study its XRD.
9. Fabricate a thin film of nanoparticles by spin coating (or chemical route)and study transmittance spectra in UV-Visible region.
10. Prepare a thin film capacitor and measure capacitance as a function of temperature or frequency.
11. Fabricate a PN diode by diffusing Al over the surface of N-type Si and study its V-I characteristic.

Reference Books:

1. C.P. Poole, Jr. Frank J. Owens, Introduction to Nanotechnology (Wiley India Pvt. Ltd.).
2. S.K. Kulkarni, Nanotechnology: Principles & Practices (Capital Publishing Company).
3. K.K. Chattopadhyay and A.N. Banerjee, Introduction to Nanoscience & Technology (PHI Learning Private Limited).
4. Richard Booker, Earl Boysen, Nanotechnology (John Wiley and Sons).

PHE104: ADVANCED SOLID STATE PHYSICS

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

Total Hours: Theory: 45, Tutorial: 15

L	T	P	Cr
3	1	0	4

Course Objectives:

This course will develop basic understanding of the solid materials and their applications. The objectives of the course are:

1. To understand the basic concepts of Intrinsic and extrinsic semiconductors.
2. To understand about the bandgap, Direct and indirect gap of semiconductors.
3. To understand various magnetic properties of a systems.
4. To learn about superconductivity, critical temperature.
5. A basic idea about the carbon nanostructures and microscopy.

Course Outcome:

At the end of the course the student is expected understand the following:

1. Carrier concentration and Fermi levels of intrinsic and extrinsic semi-conductors
2. Band Theory, Tight Binding, Pseudo potential methods and plasma oscillations.
3. Nuclear magnetic resonance, Hall effects, Elementry ideas of Quantum Hall effect, Cyclotron resonance and magnetoresistance Optical properties of nanostructured materials, modification of band gap, excitonicconfinement.
4. BCS theory, High-T_c superconductors, Josephson junctions.
5. Understanding of structure, properties and synthesis techniques of carbon nanostructures

Course Content:

UNIT 1

Intrinsic and extrinsic semiconductors. carrier concentration and Fermi levels of intrinsic and extrinsic semi-conductors. Bandgap. Direct and indirect gap semiconductors. Hydrogenic model of impurity levels.

UNIT 2

Band Theory (Advanced form Solid State Physics I), Tight Binding, Pseudo potential methods, De Haas von Alfen Effect, AC conductivity and optical properties, plasma oscillations.

UNIT 3

Defects in Crystals: Vacancy formation, Mechanism of Plastic deformation in solids, Stress Imperfections in crystals: Lattice defects & configurational entropy, vacancies, Schottky & Frankel pairs, Edge & screw dislocations (qualitative ideas), Frank-Read Sources, Dislocations in FCC, BCC and HCP structures Experimental methods of detecting defects.

UNIT 4

Magnetic properties of solids. Diamagnetism, Langevin equation. Quantum theory of paramagnetism. Curie law. Hund's rules. Paramagnetism in rare earth and iron group ions. Elementary idea of crystal field effects. Ferromagnetism. Curie-Weiss law. Heisenberg exchange interaction. Mean field theory. Antiferromagnetism. Neel point. Other kinds of magnetic order. Nuclear magnetic resonance, Hall effects, Elementry idea of Quantum Hall effect, Cyclotron resonance and magnetoresistance.

UNIT 5

Superconductivity, Survey of important experimental results. Critical temperature. Meissner effect. Type I and type II superconductors. Thermodynamics of superconducting transition. London equation. London penetration depth. Basic ideas of BCS theory. High-T_c superconductors, Josephson junctions.

References:

- John Singleton: Band theory and Electronic properties of Solids (Oxford University Press; Oxford Master Series in Condensed Matter Physics).
- Ibach & Luth: Solid State Physics.
- Elementary Dislocation Theory: Weertman and Weertman.
- M. Ali Omar: Elementary solid state physics (Addison-wesley)
- C. Kittel: Solid-state physics (Wiley eastern)(5th edition).
- Solid State Physics, A. J. Dekker, Macmillan India Ltd.
- Material Science & Engineering, V.Raghavan, Prentice –Hall of India, New Delhi (2001)

GENERIC ELECTIVES

PHG101: MECHANICS I

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

Total Hours: Theory: 45, Tutorial: 15

L	T	P	Cr
3	1	0	4

Course Objectives:

1. The course will deal, respectively, with a limited selection of specific topics included in the CBSE Std. XI and Std. XII physics curricula. The topics to be discussed are those which involve basic concepts and fundamental principles, and which therefore have wide applicability.
2. They are also the topics that are conceptually the deepest and must therefore be understood as clearly as possible.

Course Outcomes:

On successful completion of the course students will be able to

1. Revision of dimensional analysis.
2. Plot various functions.
3. Learn conservation laws of energy and linear and angular momentum and apply them to solve problems.
4. Develop understanding about gravity, angular momentum, Moment of Inertia and elastic property. First and second laws of thermodynamics, perfect gas law, properties of real gases, and the general energy equation for closed systems.
5. Learn the fundamentals of harmonic oscillator model, including damped and forced oscillators and grasp the significance of terms like quality factor and damping coefficient

Course Content:

UNIT 1

Scalars, vectors, plane polar coordinates, vectors in a plane, scalars, and pseudo-scalars, kinematics in a plane, vectors in a 3-dimensional space, the finite rotation formula

UNIT 2

Ordinary Differential Equations: 1^{st} order homogeneous differential equations. 2^{nd}order homogeneous differential equations with constant coefficients.

UNIT 3

The nature of physical laws, Fundamental constants, dimensional analysis, the fundamental forces of nature. Conservation laws and Newton's equations, conservation of angular momentum, two-body scattering, two body collision kinematic, conservative forces-the concept of a potential, simple harmonic motion, examples of simple harmonic motion,

UNIT 4

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

Reference Books:

- University Physics. F.W. Sears, M.W. Zemansky and H.D. Young, 13/e, 1986. Addison-Wesley.
- Physics–Resnick, Halliday & Walker 9/e, 2010, Wiley University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.
- Thermal Physics, S. Garg, R. Bansal and C. Ghosh, 1993, Tata McGraw-Hill.
- A Treatise on Heat, Meghnad Saha, and B.N. Srivastava, 1969, Indian Press.

PHG102: INTRODUCTION TO ELECTROMAGNETIC THEORY

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

Total Hours: Theory: 45, Tutorial: 15

L	T	P	Cr
3	1	0	4

Course Objectives:

This course introduces students to handling electromagnetic theory using vector calculus. The main objectives of the course are:

1. To introduce the basic mathematical concepts related to electromagnetic vector fields.
2. To impart knowledge on the concepts of electrostatics, electric potential, energy density and their applications.
3. Describe the concepts of Laplace’s and Poisson’s equations and Uniqueness theorem
4. To impart knowledge on the concepts of magnetostatics, magnetic flux density, scalar and vector potential and its applications.
5. To impart knowledge on the concepts of Faraday’s law, induced emf and Maxwell‘s equations.
6. To impart knowledge on the concepts of Concepts of electromagnetic waves.

Course Outcomes:

Student should be able to

1. Handle problems that are more complicated (electric field and potential due various charge configuration).
2. Understand and describe the concepts of Laplace’s and Poisson’s equations and Uniqueness theorem.
3. Explain the concept of Capacitor’s and use the method of images and determine potential due tovarious charge distributions.
4. Explain the concept of magnetic fields and determine field due to solenoid and toroid.
5. Explain the concept of electromagnetic induction, and its applications.

Course Content:

UNIT 1

Electric Field, Electric Potential and Electric Potential Energy

Scalar and vector product, gradient divergence, Coulomb's law Divergence of electric field Gauss' law Curl of electric field Stokes' theorem Electrostatic potential. Laplace's equation for electrostatic potential Laplace's equation in other fields Uniqueness of solution of Laplace's equation Poisson equation and uniqueness of its solution Method of images for planar surfaces Work and energy in electrostatics.

UNIT 2

Dielectric Properties of Matter:

Conductors and capacitors Reciprocity theorem Polarization and bound charges Linear dielectrics Electric displacement Fields in dielectrics.

UNIT 3

Magnetic Field:

Magnetic field due to a magnet Magnetic field due to a steady current Divergence and curl of magnetic field Ampere's law. The vector potential Magnetization and bound currents. Magnetic fields in matter.

UNIT 4

Electromagnetic Induction and Electromagnetic waves:

Maxwell's equations Work done by electromagnetic field Poynting's theorem Momentum in electromagnetic field Angular momentum in electromagnetic field Electromagnetic waves: the wave equation. Wave equation Plane electromagnetic waves Energy carried by electromagnetic waves Pressure due to electromagnetic waves Refection and transmission of electromagnetic waves Reflection and transmission of electromagnetic waves

Reference Books

- Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House
- A Text Book of Practical Physics, I.Prakash & Ramakrishna, 11^{th} Ed., 2011, KitabMahal
- Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4^{th} Edition, reprinted 1985, Heinemann Educational Publishers
- A Laboratory Manual of Physics for undergraduate classes, D.P. Khandelwal, 1985, VaniPub.

PHG103: DIGITAL AND ANALOG SYSTEMS

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

Total Hours: Theory: 45, Tutorial: 15

L	T	P	Cr
3	1	0	4

Course Objectives:

The course will lead to understand about:

1. Difference between analog and digital circuits.
2. Binary numbers, logic gates and Boolean algebra
3. Concepts of semiconductor devices and amplifiers.
4. Basic understanding of operational amplifiers.

Course Outcomes:

After successful completion of the course, the student should be able to:

1. Learn the difference between analog and digital systems.
2. Learn about digital circuits, logic gates, Boolean algebra and various operation of digital systems
3. Explain about semiconductor devices like PN junctions, transistors and amplifiers.
4. Understand about operational amplifiers and oscillators.

Course Content:

UNIT 1

Digital Circuits

Difference between Analog and Digital Circuits. Binary Numbers. Decimal to Binary and Binary to Decimal Conversion, AND, OR and NOT Gates (Realization using Diodes and Transistor). NAND and NOR Gates as Universal Gates. XOR and XNOR Gates.

De Morgan's Theorems. Boolean Laws. Simplification of Logic Circuit using Boolean Algebra. Fundamental Products. Min terms and Max terms. Conversion of a Truth Table into an Equivalent Logic Circuit by (1) Sum of Products Method and (2) Karnaugh Map.

UNIT 2

Semiconductor Devices and Amplifiers:

Semiconductor Diodes: P and N type semiconductors. Barrier Formation in PN Junction Diode. Qualitative Idea of Current Flow Mechanism in Forward and Reverse Biased Diode. PN junction and its characteristics. Static and Dynamic Resistance. Principle and structure of (1) LEDs, (2) Photodiode, (3) Solar Cell.

Bipolar Junction transistors: n-p-n and p-n-p Transistors. Characteristics of CB, CE and CC Configurations. Current gains α and β. Relations between α and β. Load Line analysis of Transistors. DC Load line & Q-point. Active, Cutoff & Saturation regions. Voltage Divider Bias Circuit for CE Amplifier. Analysis of single-stage CE amplifier using hybrid Model. Input & output Impedance. Current, Voltage and Power gains. Class A, B &C Amplifiers.

UNIT 3

Operational Amplifiers (Black Box approach):

Characteristics of an Ideal and Practical Op-Amp (IC 741), Open-loop and closed- loop Gain. CMRR, concept of Virtual ground. Applications of Op-Amps: (1) Inverting and non-inverting amplifiers, (2) Adder, (3) Subtractor, (4) Differentiator, (5) Integrator

UNIT 4

Sinusoidal Oscillators: Barkhausen's Criterion for self-sustained oscillations. Determination of frequency RC oscillator.

Reference Books:

- Integrated Electronics, J. Millman and C.C. Halkias, 1991, Tata Mc-GrawHill.
- Electronic devices & circuits, S. Salivahanan & N.S. Kumar, 2012, Tata Mc-Graw Hill
- Microelectronic Circuits, M.H. Rashid, 2nd Edn., 2011, Cengage Learning.
- Modern Electronic Instrumentation and Measurement Tech., Helfrick and Cooper, 1990, PHI Learning
- Digital Principles and Applications, A.P. Malvino, D.P. Leach and Saha, 7th Ed., 2011, Tata McGrawHill
- Fundamentals of Digital Circuits, A. Anand Kumar, 2nd Edition, 2009, PHI Learning Pvt. Ltd.

PHG104: ELEMENTS OF MODERN PHYSICS

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

Total Hours: Theory: 45, Tutorial: 15

L	T	P	Cr
3	1	0	4

Course Objectives:

The objectives of the course are:

1. To describe the concept of plank hypothesis of photons, Black body radiation of matter.
2. To determine the uncertainty in position and momentum by Heisenberg uncertainty principle.
3. To understand the size and structure of atomic nucleus and its relation with atomicweight.

Course Outcomes:

Upon successful completion of this course, it is intended that a student will be able to:

1. Calculate the Wave amplitude and wave functions.
2. Understand the concept of alpha decay and beta decay.
3. Estimating semi-empirical mass formula and binding energy by liquid drop model.

Course Content:

UNIT 1

Planck's quantum, Planck's constant and light as a collection of photons; Photo- electric effect and Compton scattering. De Broglie wavelength and matter waves; Davisson-Germer experiment.

UNIT 2

Position measurement- gamma ray microscope thought experiment; Wave-particle duality, Heisenberg uncertainty principle- impossibility of a particle following a trajectory; Energy-time uncertainty principle.

Matter waves and wave amplitude; Schrodinger equation for non-relativistic particles; Momentum and Energy operators; stationary states; physical interpretation of wavefunction, probabilities and normalization; Probability and probability current densities in one dimension.

UNIT 3

One dimensional infinitely rigid box- energy eigenvalues and eigenfunctions, normalization; Quantum dot as an example; Quantum mechanical scattering and tunneling in one dimension - across a step potential and across a rectangular potential barrier.

Size and structure of atomic nucleus and its relation with atomic weight; Impossibility of an electron being in nucleus as a consequence of the uncertainty principle. Natureof nuclear force, NZ graph, semi-empirical mass formula and binding energy.

UNIT 4

Radioactivity: stability of nucleus; Law of radioactive decay; Meanlife and half-life; α decay; β decay - energy released, spectrum and Pauli's prediction of neutrino; γ-ray emission. Fission and fusion - mass deficit, relativity and generation of energy; Fission – nature of fragments and emission of neutrons. Nuclear reactor: slow neutrons interactingwith Uranium 235; Fusion and thermo nuclear reactions.

Reference Books:

- Concepts of Modern Physics, Arthur Beiser, 2009, McGraw-Hill
- Modern Physics, J.R. Taylor, C.D. Zafiratos, M.A. Dubson,2009, PHI Learning
- Six Ideas that Shaped Physics: Particle Behave like Waves, Thomas A. Moore,2003, McGraw Hill
- Quantum Physics, Berkeley Physics, Vol.4. E.H. Wichman, 2008, Tata McGraw-Hill Co.
- Modern Physics, R.A. Serway, C.J. Moses, and C.A. Moyer, 2005, Cengage Learning

SKILL ENHANCEMENT COURSE

PHS101: BASICS OF INSTRUMENTS

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

Total Hours: Theory: 15, Practical: 30

Course Objectives:

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

Course Outcomes:

At the end of this course the students will learn the following. •

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

Course Content:

UNIT 1

Basics of Measurement: Instruments accuracy, precision, sensitivity, resolution range etc. Errors in measurements and loading effects. Working principle of time interval, frequency and period measurement, time-base stability, accuracy and resolution.

UNIT 2

Multimeter: Measurement of dc voltage and dc current, ac voltage, ac current and Specifications of electronic voltmeter/multimeter and their significance. AC milli-voltmeter, working of a digital multimeter.

UNIT 3

Cathode Ray Oscilloscope: Specifications of CRO with block diagram and their significance. Measurement of voltage (dc and ac), frequency and time period. Special features of dual trace. Digital storage Oscilloscope: principle of working.

UNIT 4

Signal and Pulse Generators: Block diagram and specifications of low frequency signal and pulse generators. Distortion factor meter, wave analysis.

References:

Essential Readings: 1)

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

Additional Readings:

- A text book in Electrical Technology - B L Theraja - S Chand and Co.
- Performance and design of AC machines - M G Say ELBS Edn.

PRACTICAL Basic of Instruments (Credit:01, 30 hours)

List of Experiments:

1. To observe the loading effect of a multimeter while measuring voltage across a low resistance and high resistance.
2. To observe the limitations of a multimeter for measuring high frequency voltage and currents.
3. To measure Q of a coil and its dependence on frequency, using Q-meter.
4. Measurement of voltage, frequency, time period and phase using an oscilloscope.

5. Measurement of time period, frequency, average period using universal counter/frequency counter.
6. Measurement of rise, fall and delay times using oscilloscope.
7. Measurement of distortion of a RF signal generator using distortion factor meter.

Open Ended Experiments:

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

PHS102 : COMPUTATIONAL PHYSICS

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

Total Hours: Theory: 15, Practical: 30

L	T	P	Cr
1	0	1	2

Course Objectives:

The aim of this course is not just to teach computer programming and numericalanalysis but to emphasize its role in solving problems in Physics.

1. Highlights the use of computational methods to solve physical problems.
2. Use of computer language as a tool in solving physics problems (applications).
3. Course will consist of hands-on training on the Problem solving on computers.

Course Outcomes:

This course will enable the students to

1. Learn, write and run FORTRAN programs in the Linux system. In particular, theywill attempt the following exercises: (i) Exercises on syntax on usage of FORTRAN. (ii) Usage of GUI windows, Linux commands, familiarity with DOS.
2. Learn the skills for writing a flow chart and then writing the corresponding program for a specific problem using the C/ C++/FORTRAN language
3. Attempt the following exercises: (i) Exercises on syntax on usage of FORTRAN. (ii) Usage of GUI windows, Linux commands, familiarity with DOS commands and working in an editor to write sources codes in FORTRAN. (iii) To print out all natural even/ odd numbers between given limits. (iv) To find maximum,minimum and range of a given set of numbers.

Course Content:

UNIT 1

Introduction: Importance of computers in Physics, paradigm for solving physics problems for solution**.** Usage of linux as an Editor. **Algorithms and Flowcharts:** Algorithm: Definition, properties and development. Flowchart: Concept of flowchart, symbols, guidelines, types. Examples: Cartesian to Spherical Polar Coordinates, Rootsof Quadratic Equation, Sum of two matrices, Sum and Product of a finite series, calculation of sin(x) as a series, algorithm for plotting (1) lissajous figures and (2) trajectory of a projectile thrown at an angle with the horizontal.

UNIT 2

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

UNIT 3

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

Programming:

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

Hands on exercises:

1. To compile a frequency distribution and evaluate mean, standard deviation etc.
2. To evaluate sum of finite series and the area under a curve.
3. To find the product of two matrices
4. To find a set of prime numbers and Fibonacci series.
5. To find the roots of a quadratic equation.

Reference Books:

- Introduction to Numerical Analysis, S.S. Sastry, 5th Edn., 2012, PHI Learning Pvt.Ltd.
- Computer Programming in Fortran 77". V. Rajaraman (Publisher:PHI).
- LaTeX–A Document Preparation System", Leslie Lamport (Second Edition, Addison-Wesley,1994).
- Gnuplot in action: understanding data with graphs, Philip K Janert, (Manning2010)
- Schaum's Outline of Theory and Problems of Programming with Fortran, S Lipsdutz and A Poe, 1986Mc-Graw Hill BookCo.
- Computational Physics: An Introduction, R. C. Verma, et al. New Age International Publishers, NewDelhi(1999)
- AfirstcourseinNumericalMethods,U.M.AscherandC.Greif,2012,PHILearning
- Elementary Numerical Analysis, K.E. Atkinson, 3 rdEdn., 2007 , Wiley IndiaEdition.

PHS103-: PHYSICS WORKSHOP SKILL

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

Total Hours: Theory: 15, Practical: 30

L	T	P	Cr
1	0	1	2

Course Objectives:

The aim of this course is

1. To familiarize the students with basic conversions and measuring scales.
2. To familiar and experience with various machine tools, lathes, shapers, drilling machines, cutting tools, welding sets.
3. He/she will also acquire skills in the usage of multimeters, soldering iron, oscilloscopes, power supplies and relays.

Course Outcomes:

Students would achieve:

1. The ability to make simple length, height, time, area, volume measurements.
2. Mechanical skills needed to the workshop practice.
3. Hand on experience of workshop practice by doing casting, foundry, machining, welding and learn to use various machine tool like lathe shaper, milling and drilling machines etc. and working with wooden and metal blocks.
4. Electrical and electronics skills related to the measurement of various electrical and electronics quantities.

Course Content:

Introduction: Measuring units. conversion to SI and CGS. Familiarization with meter scale, Vernier calliper, Screw gauge and their utility. Measure the dimension of a solid block, volume of cylindrical beaker/glass, diameter of a thin wire, thickness of metal sheet, etc. Use of Sextant to measure height of buildings, mountains, etc.

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

Electrical and Electronic Skill: Use of Multimeter. Soldering of electrical circuits having discrete components (R, L, C, diode) and ICs on PCB. Operation of oscilloscope. Making regulated power supply. Timer circuit, Electronic switch using transistor and relay.

Reference Books:

- A text book in Electrical Technology - B L Theraja – S. Chand and Company.
- Performance and design of AC machines – M.G. Say, ELBS Edn.
- Mechanical workshop practice, K.C. John, 2010, PHI Learning Pvt. Ltd.
- Workshop Processes, Practices and Materials, Bruce J Black 2005, 3rd Edn.,Editor Newnes [ISBN:0750660732]
- New Engineering Technology, Lawrence Smyth/Liam Hennessy, The Educational Company of Ireland [ISBN:0861674480]

PHS104 : SCIENTIFIC WRITING

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

Total Hours: Theory: 15, Practical: 30

L	T	P	Cr
1	0	1	2

Course Objectives:

The aim of this course is not just to teach scientific word processing and plotting on UNIX/ LINUX based environments.

1. Highlights the basics of word processing using LaTeX.
2. Use of Gnuplot for 2D and 3D plotting.
3. Course will consist of hands-on training on the scientific writing.

Course Learning Outcomes:

This course will enable the students to

4. Learn "Scientific Word Processing", particularly, how to use the LaTeX software in writing articles and papers which include mathematical equations and diagrams.
5. Students should learn the basics of Gnuplot on 2D and 3D plots.

Course Content:

UNIT 1

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

UNIT 2

Basics of power point presentations using LaTeX: Introduction to the basic environments, layouts of presentations. Inclusion and editing of equations, figures, tables and other objects.

UNIT 3

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

Hands on exercises:

1. To write program to open a file and generate data for plotting using Gnuplot.
2. Plotting trajectory of a projectile projected horizontally.
3. Plotting trajectory of a projectile projected making an angle with the horizontally.
4. Creating an input Gnuplot file for plotting a data and saving the output for seeingon the screen. Saving it as an eps file and as a pdf file.
5. To find the roots of a quadratic equation.
6. Motion of a projectile using simulation and plot the output for visualization.
7. Motion of particle in a central force field and plot the output for visualization.

Reference Books:

- LaTeX–A Document Preparation System", Leslie Lamport (Second Edition, Addison-Wesley,1994).
- Gnuplot in action: understanding data with graphs, Philip K Janert, (Manning2010)