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DEPARTMENT OF PG STUDIES & RESEARCH IN PHYSICS

Syllabus of
Masters' Degree Programme
in Physics

(CHOICE BASED CREDIT SYSTEM (CBCS) SEMESTER SCHEME)

2016-17 Onwards

(EFFECTIVE FROM ACADEMIC YEAR 2024-25)

Approved by the BOS meeting held on 29-02-2024

Approved in Academic council meeting held on 23-03-2024

INDEX

PREAMBLE

Revision of Syllabus for the Two years Master Degree (Choice Based Credit System-Semester Scheme) Programme in Physics.

Board of Studies in Physics has revised and prepared the Syllabus (CBCS scheme) for the Physics course in its meeting held on 03rd December, 2022 based on the UGC letter (Ref, No. MU/ACC/CR.38/CBCS (PG)/2015-16 dated 05-05-2016) to offer Hardcore, Softcore and Open Elective courses with total 92 credits for the entire programme.

The BOS has prepared the syllabus by adopting the pattern of 13 hardcore and 10 softcore along with one project. Total credits for hardcore is 48, soft core is 34, 4 for project and 6 credits for open elective.

Detailed syllabus was prepared for all the four semesters.

The revised syllabus is designed to impart quality education by incorporating skill components with practical knowledge. The syllabus has been prepared in a participatory manner, after discussions with a panel of members consisting of subject experts, industrial experts and meritorious alumnus of the department by referring the existing syllabi, U.G.C. model curriculum and the syllabi of other Universities and National Institutes.

The syllabus is structured in a view to prepare the students for higher studies and employability. The curriculum imparts knowledge to the students on the skills required for contributing to the industry and academic Institutions. Also, sufficient emphasis is given in the syllabus for training in laboratory skills and instrumentation. The units of the syllabus are well defined. The number of contact hours required for each unit is also given. A list of reference books is provided at the end of the each semester.

ELIGIBILITY FOR ADMISSION

B.Sc. Degree from recognized University, with Physics as one of the major/optional/special subjects, at UG level with 45% aggregate excluding languages (40% for SC/ST/Category–1 candidates). Mathematics in BSc is mandatory.

PROGRAMME OBJECTIVES

The syllabus aims to enable students to:

- Prepare the students to gain sound knowledge on principles and methodologies of Physics.
- Understand and analyze the problems using the acquired scientific knowledge.
- Develop the capacity to adopt effectively and implement the information available with them.
- Acquire good laboratory skills and practice safety measures when using equipment and apparatus.
- Apply the basic knowledge in everyday life to solve the problems and for the betterment of society.

PROGRAMME SPECIFIC OUTCOMES

The learner will be able to:

PSO1: Become employable, acquiring understanding of the subject.

PSO2: Be familiar with good laboratory skills.

PSO3: Appreciate, understand and use the scientific method in the solving of problems.

PSO4: Show the specialized knowledge & skill sets through choice of soft core papers.

PSO5: Be readily available manpower for various public and private sector industries.

PSO6: Exhibit familiarity with hands on experience in research and equipment handling.

PSO7: Show an interest to become young physicists to showcase their talents in the field of Physics.

PSO8: Demonstrate the ability to establish start-ups in the field of application of Physics for the progress of the society.

COURSE/CREDIT PATTERN

Semester	**Theory (Hard core)**	**Credits**	**Practical (Soft/ Hard)**	**Credits**	**Theory (Elective) Soft**	**Credits**	**Theory (Open Elective)**	**Credits**	**Project (Hard /Soft)**	**Credits**	**Total Credits**
I	4 H	4 x 4 = 16	2 S	6	-	-	-	-	-	-	22
II	4 H	4 x 4 = 16	2 S	6	-	-	1	3*	-	-	25
III	2 H	2 x 4 = 8	2 S	6	2 S	2 x 4 = 8	1	3*	-	-	25
IV	2 H	2 x 4 = 8	-	-	2 S	2 x 4 = 8	-	-	1 H	4	20
Total credit from all the four semesters (I, II, III and IV): 22 + 25 + 25 + 20 = **92**											

Details of course and credits for four semesters:

Hardcore Credits with %	**Softcore Credits with %**	**Total Credits Hard + Soft without Open Elective**	**Open Elective Credits**	**Total Credits Hard + Soft + Open Elective**
52 (60.47)	34 (39.53)	86	6*	86 + 6* = 92

Total credits from all the four semesters = 86+6*= 92 Total hardcore credits = 48

Project (Hardcore) Credits = 04 Total Softcore credits = 34

Open elective credits = 6 (Open electives are graded and not included in the CGPA).

List of Open Elective & Certificate Courses offered by the Department

S No	Title of Open Elective	Credits/Hrs/Sem offered
1	PHOE 551 Basic Nuclear & Radiation Physics	3/39/II Sem
2	PHOE 552 Applied Solid State Physics	
3	PHOE 553 Physics of the Cosmos	
4	PHOE 601 Physics of the Micro World	3/39/III Sem
5	PHOE 602 Everyday Electronics	
6	PHOE 603 Physics of Sight & Sound	

Title of Certificate Course offered:

PHC1: Research Methodology & Computational Techniques

No of Hrs: 21 + 21 = 42hrs divided over two semesters

Offered in: III & IV sem.

NOTE:

FIRST SEMESTER: The first semester consists of four theory courses which are hardcore (4 hours per week for each course and shall carry 4 credits for each course) and two practicals (softcore 6 hours per week for each practical course and each practical course carries 3 credits). The duration of the lab is 3 hours. The students have to come twice a week for each of the practical course. Two hours of seminars/tutorials/skill components per week.

SECOND SEMESTER: The second semester consists of four theory courses which are hardcore (4 hours per week for each course and shall carry 4 credits for each of the course) and two practical (softcore 6 hours per week for each practical course and each practical course shall carry 3 credits). The duration of the lab is 3 hours. The students have to come twice a week for each of the practical course. In addition there shall be an open elective course to be opted by the student from other departments. The open elective course is a softcore course (3 hours per week and shall carry 3 credits). Two hours of seminars/tutorials/skill components per week.

THIRD SEMESTER: The third semester consists of four theory courses, two general theory courses and two elective courses. The elective courses are offered in each of the two specializations, condensed matter physics and electronics. The two general courses are hardcore (4 hours per week and shall carry 4 credits). The two elective courses offered in each of the two specializations are softcore courses (4 hours per week and shall carry 4 credits). The two practical courses for each of the above-mentioned specialization are softcore courses (6 hours per week and shall carry 3 credits for each of the practical course). The duration of the lab is 3 hours for each practical. The students have to come twice a week for each of the practical courses. In addition there is an open elective course to be opted by the student from other departments. The open elective is a softcore course (3 hours per week and shall carry 3 credits). Two hours of seminars/tutorials/skill components per week. In addition, the department offers a value-added course of 42hrs as a certificate course (21hrs in this semester).

FOURTH SEMESTER: The fourth semester consists of four theory courses, two general theory courses and two elective courses. The elective courses are offered in each of the two specializations, condensed matter physics and electronics. The two general courses are hardcore (4 hours per week and shall carry 4 credits). The two elective courses offered in each of the two specializations are softcore courses (4 hours per week and shall carry 4 credits). There shall be a compulsory project work, which has to be under taken by all the students of the fourth semester. The project work is a hardcore having 8 hours per week with 4 credits. Two hours of seminars/tutorials/skill components per week. Further, remaining 21hrs of certificate course is continued.

MSc DEGREE PROGRAMME IN PHYSICS

CONTENT OF THE COURSE

Semester	Theory/ Practicals	Exam Hours	Marks End Semester + Internal Assessment	Credits	Total
I	4 Theory courses (Hardcore)	3 hrs each	70 + 30* each	4 x 4 = 16	400
	2 Practicals (Softcore)	3 hrs each	70 + 30* each	2 x 3 = 6	200
II	4 Theory courses (Hardcore)	3 hrs each	70 + 30* each	4 x 4 = 16	400
	2 Practicals (Softcore)	3 hrs each	70 + 30* each	2 x 3 = 6	200
	1 Open Elective (Theory)	3 hrs	70 + 30*	1 x 3 = 3	100
III	4 Theory courses i) 2 Hardcore (4 Credits) ii) 2 Softcore (4 Credits)	3 hrs each	70 + 30* each	2 x 4 = 8 2 x 4 = 8	400
	2 Practicals (Softcore)	3 hrs each	70 + 30* each	2 x 3 = 6	200
	1 Open Elective (Theory)	3 hrs	70 + 30*	1 x 3 = 3	100

IV	4 Theory courses i) 2 Hardcore (4 Credits) 2 Softcore (4 Credits)	3 hrs each	70 + 30* each	2 x 4 = 8 2 x 4 = 8	400
	Project (Hardcore)		100	1 x 4 = 4	100
Grand Total					**2500**

*Internal Assessment

NOTE:

BASIS FOR INTERNAL ASSESSMENT: Internal assessment marks in theory courses shall be based on two tests in each theory course, attendance, assignments, seminars and the total internal assessment marks for each course is 30. Practical internal assessment marks is based on model examination, viva-voce, practical records and regular practical performance in the semesters and carries 30 marks for each practical course.

PROJECT REPORT: There shall be a project in the fourth semester for all the two specializations. The project report shall be in the form of a project report/dissertation and carries 100 marks and has 4 credits. A dissertation/project report shall be evaluated by two examiners, one external and one internal from out of the panel of examiners prepared by the B.O.S.

CERTIFICATE COURSE: A certificate shall be given on successful completion of the course based on continuous evaluation (seminars, assignments and overall involvement of the student).

SDM COLLEGE (AUTONOMOUS), UJIRE

MSc DEGREE PROGRAMME IN PHYSICS: SEMESTER SCHEME

COURSE TITLES & CREDITS

SEMESTER	Description of the courses	Teaching Hrs/ week	Credit Hard(H)/Soft(S)/ Open elective(OE)	Max Marks: Exam + IA = Total
I SEMESTER				
PHHT 501	Methods of Mathematical Physics I	4	4 H	70 + 30
PHHT 502	Quantum Mechanics I	4	4 H	70 + 30
PHHT 503	Classical Mechanics	4	4 H	70 + 30
PHHT 504	Electrodynamics	4	4 H	70 + 30
PHSP 501	Physics Practical I (General)	6	3 S	70 + 30
PHSP 502	Physics Practical II (Electronics)	6	3 S	70 + 30
II SEMESTER				
PHHT 551	Mathematical Physics II and C Programming	4	4 H	70 + 30
PHHT 552	Quantum Mechanics II	4	4 H	70 + 30
PHHT 553	Nuclear and Radiation Physics	4	4 H	70 + 30
PHHT 554	Condensed Matter Physics and Electronics	4	4 H	70 + 30
PHOE 551	Basic Nuclear and Radiation Physics	3*	3S (OE)	70 + 30
PHOE 552	Applied Solid State Physics			

PHOE 553	Physics of the Cosmos			
PHSP 551	Physics Practical III (General)	6	3 S	70 + 30
PHSP 552	Physics Practical IV (Electronics)	6	3 S	70 + 30

SEMESTER	**Description of the courses**	**Teaching Hrs/ week**	**Credit Hard(H)/Soft(S) /Open elective(OE)**	**Max Marks: Exam + IA = Total**
III SEMESTER				
PHHT 601	Atomic and Molecular Physics	4	4 H	70 + 30
PHHT 602	Thermodynamics and Statistical Physics	4	4 H	70 + 30
PHST 601	Condensed Matter Physics I	4	4 S	70 + 30
PHST 602	Condensed Matter Physics II	4	4 S	70 + 30
PHST 603	Electronics I	4	4 S	70 + 30
PHST 604	Electronics II	4	4 S	70 + 30
PHOE 601	Physics of the Micro World	3*	3 S (OE)	70 +30
PHOE 602	Everyday Electronics			
PHOE 603	Physics of Sight and Sound			
PHSP 601	Condensed Matter Physics - Practical I	6	3 S	70 + 30
PHSP 602	Condensed Matter Physics - Practical II	6	3 S	70 + 30
PHSP 603	Electronics - Practical I	6	3 S	70 + 30
PHSP 604	Electronics - Practical II	6	3 S	70 + 30
IV SEMESTER				

PHHT 651	Laser Physics, Vacuum Techniques and Cryogenics	4	4 H	70 + 30
PHHT 652	Astrophysics and Relativity	4	4 H	70 + 30
PHST 651	Condensed Matter Physics III	4	4 S	70 + 30
PHST 652	Condensed Matter Physics IV	4	4 S	70 + 30
PHST 653	Electronics III	4	4 S	70 + 30
PHST 654	Electronics IV	4	4 S	70 + 30
PHPD 651	Project work (with viva)	8	4 H	100

I SEMESTER

PHHT 501: METHODS OF MATHEMATICAL PHYSICS I

Teaching hours: 4 per week

No of credits: 4

Objectives & Skill Components:

1. To acquaint the students with various mathematical techniques used in Physics
2. To familiarize the notations, symbols & terminologies associated with (Mathematical) Physics
3. To teach the mathematical principles involved in solving problems in Physics
4. To acclimatize the various applications of mathematical methods of Physics

Course Outcomes:

CO1: Understand that mathematics can be used as an effective tool in solving physical problems.

CO2: Appreciate the utility and ingenuity of various mathematical theorems when applied to physical principles.

CO3: Be familiar with the abstraction of physical concepts when codified in mathematical language.

CO4: Understand and apply mathematical formulation in various branches of Physics

UNIT - I Vector analysis and curvilinear coordinates 13 hrs.

Review of vector analysis and vector calculus. Integration of vector functions - line integrals, surface integrals and volume integrals – Mention of vector theorems (Gauss, Green's and Stokes') and their applications in Physics. Generalized coordinates - elements of curvilinear coordinates - transformation of coordinates - orthogonal curvilinear coordinates - unit vectors - expression for arc length, volume element. The gradient, divergence and curl in curvilinear coordinates. Laplacian in orthogonal curvilinear coordinates, spherical polar and cylindrical coordinates.

UNIT - II Complex analysis 13 hrs.

Review of functions of a complex variable – Cauchy Riemann conditions. Cauchy integral theorem, Cauchy integral formula. Contour integration. Taylor & Laurent series. Zeroes & isolated singular points, simple pole, m^{th} order pole. Cauchy's residue theorem. Principal value. Evaluation of different forms of definite integrals. A digression on Jordan's lemma.

UNIT - III Partial differential equations **13 hrs.**

Review of differential equations. First order partial differential equations for a function of two variables. Linear second order partial differential equations. Classification into elliptic, parabolic and hyperbolic types. Boundary value problems - solutions by method of separation of variables - 1, 2 & 3 dimensional wave equation and diffusion equation in different coordinates.

UNIT - IV Special functions **13 hrs.**

Beta and gamma functions, their properties and applications. Power series method for solving ordinary differential equations. Legendre differential equation and solutions, Legendre polynomials – generating function and recurrence relations, orthogonality of Legendre polynomials. Bessel equation and solutions, Bessel functions and properties - generating function and recurrence relations, orthogonality of Bessel functions. Solution of Hermite equation – Hermite polynomials – generating functions and recurrence relations, orthogonality of Hermite's polynomials.

References:

1. Arfken G & Weber, 'Mathematical Methods for Physicists' (Academic Press)
2. Harper C, 'Introduction to Mathematical Physics' (PHI, 1978)
3. Harry Lass, 'Vector and Tensor Analysis' (McGraw Hill, 1950)
4. Mary L Boas, 'Mathematical Methods in the Physical sciences' (John Wiley)
5. Spiegel M R, 'Vector Analysis' (Schaum series, McGraw Hill, 1997)
6. Chattopadhyaya P K, 'Mathematical Physics' (Wiley Eastern, 1990)
7. Ayres F, 'Differential Equations' (Schaum series, McGraw Hill)
8. Sneddon I A, 'Elementary Partial Differential Equations' (McGraw Hill, 1957)
9. Bose A K and Joshi M C, 'Methods of Mathematical Physics' (McGraw Hill)
10. Kreysig E, 'Advanced Engineering Mathematics' (Wiley Eastern, 1969)
11. Mathews J and Walker R L, 'Mathematical Methods of Physics' (W A Benjamin, Inc, 1979).
12. Joglekar.S, 'Mathematical Physics Vol 1&2' (Universities Press, 2005).
13. Shankar Rao, "Partial Differntial Equations" (PHI Learning Pvt. Ltd., 2010).
14. HK Dass, 'Mathematical Physics' (S Chand, 2018)

PHHT 502: QUANTUM MECHANICS I

Teaching hours: 4 per week

No of credits: 4

Objectives & Skill Components:

1. To introduce the students to the world of microscopic particles and their *seemingly* bizarre nature
2. To familiarize them to the limitations of Classical, Newtonian laws
3. To teach the laws of the micro-world, its nature and implications
4. To teach them the scope, nature and interpretation of the quantum world.

Course Outcomes:

CO1: Appreciate the paradigm-shift in the laws of microscopic particles.

CO2: Understand the laws of Physics at the level of elementary particles.

CO3: Appreciate the deep and profound ideas that govern the particles at the quantum scale.

CO4: Show an understanding of the nature and properties of various systems from the perspective of quantum mechanical principles.

UNIT - I General formulation of quantum mechanics 13 hrs.

Review of basic concepts, Schrodinger's equation & probability interpretation, principle of superposition, normalization, equation of continuity, Wave packet and uncertainty relations. Postulates of QM, states & dynamical variables, operators & expectation values, eigenvalues & eigenfunctions. Ehrenfest theorem & its physical implication, Schrodinger equation as an eigenvalue problem.

UNIT - II Matrix formalism of quantum mechanics 13 hrs.

Linear vector spaces & its properties - orthogonality and linear independence, bases and dimensions, completeness. Hilbert space, Hermiticity & Hermitian operators, Unitarity & unitary operators. Bra & Ket notation, Schwarz inequality, generalized uncertainty relation, time evolution & quantum equations of motion- Schrodinger & Heisenberg pictures, Interaction picture (qualitative).

UNIT - III Stationary states and eigenvalue problems 13 hrs.

The time independent Schrodinger equation - particle in square well - bound states - normalized states. Potential step and rectangular potential barrier - reflection and transmission coefficients - tunneling of particles. Simple harmonic oscillator - Schrödinger equation and its energy eigen values and eigen functions. Properties of stationary states. Solution of the Linear Harmonic Oscillator using Operator Method.

UNIT - IV Angular momentum and bound state problem 13 hrs.

Angular momentum operators, eigen value equation for L^2 and L_z - Separation of variables. Admissibility conditions on solutions – eigenvalues and eigenfunctions. Particle in a central potential - radial equation. The hydrogen atom - solution of the radial equation - energy levels. Stationary state wave functions - bound states.

References:

1. Powell and Crassman, 'Quantum Mechanics' (Addison Wesley, 1961)
2. Mathews P M and Venkatesan K, 'A Text Book of Quantum Mechanics' (Tata
3. McGraw Hill, 1977)
4. Sakurai J J, 'Modern Quantum Mechanics' (Addison Wesley, 1994)
5. Cohen Tannoudji C, Diu B and Laloe F, 'Quantum Mechanics', Vol. I (John Wiley)
6. Schiff L I, 'Quantum Mechanics', III Edn. (McGraw Hill)
7. Gasirowicz, 'Quantum Physics' (Wiley, 1974)
8. Robert Eisberg & R Resnick, 'Quantum Physics of Atoms, Molecules, Solids, Nuclei & Particles', II Edn. (John Wiley & Sons)
9. Wichmann E H, 'Quantum Physics' (McGraw Hill, 1971)
10. V Devanathan, 'Quantum Mechanics', (Alpha Science International, 2011)
11. Arul Das, 'Quantum Mechanics', (PHI Learning Pvt. Ltd., 2010)
12. Zettili, 'Quantum Mechanics', (Wiley, 2009)
13. Liboff, 'Quantum Mechanics', (Pearson Education Inc, 2009)
14. Ghatak A K and Lokanathan S, 'Quantum Mechanics' (McMillan India)
15. Shankar R, 'Principles of Quantum Mechanics' (Plenum, 1980)
16. Griffiths D. J., 'Quantum Mechanics', (Pearson Education Inc, 2005)
17. Merzbacker E, 'Quantum Mechanics', (Wiley, 1998)

PHHT 503: CLASSICAL MECHANICS

Teaching hours: 4 per week

No of credits: 4

Objectives & Skill Components:

1. Basic principles of classical physics serving as foundation to modern topics like quantum mechanics, nuclear physics, solid state physics, electronics etc.
2. Understanding the Lagrangian and Hamiltonian formalism of Classical mechanics
3. Transition to a rigorous mathematical physics formulation of dynamics and kinematics
4. Understanding the nature of central forces and the Centre of Mass picture
5. A basic familiarity of Chaos in classical systems, nature of non linearity and the applications
6. A cursory venture into fractals and synchronization

Course Outcomes:

CO1: Appreciate the laws of classical particles.

CO2: Understand the laws of Physics at the macroscopic scale.

CO3: Appreciate the deep and profound ideas that governing Nature.

CO4: Show an understanding of the nature and properties of various systems.

UNIT -I - System of particles and Lagrangian formulation: 13 hrs.

System of Particles: Centre of mass, total momentum, angular momentum and kinetic energy of a system of particles, Newton's laws, conservation of linear momentum, angular momentum and energy.

Lagrangian Formulation: Constraints and their classification, degree of freedom, generalized co-ordinates, virtual displacement, D'Alembert's principle

Symmetry of space and time: Conservation of linear momentum, angular momentum and energy.

UNIT- II - Hamiltonian formalism and canonical transformations: 13 hrs.

Hamiltonian formalism: Generalized momenta, Hamiltonian function, Physical significance and the Hamilton's equations of motion, Examples of (a) The Hamiltonian of a particle in a central force field, (b) the simple harmonic oscillator. Principle of least action: derivation of equation of motion, variation and end points.

Canonical transformations: Generating functions (four basic types), examples of canonical transformations, the Harmonic oscillator in one dimension, Poisson brackets, equations of motion in terms of Poisson brackets, properties of Poisson brackets (anti-symmetry, linearity and Jacobi Identity), The Hamilton-Jacobi equation, Solution of linear harmonic oscillator using Hamilton-Jacobi method.

UNIT- III - Central forces: 13 hrs.

Definition and characteristics. Reduction of two particle equations of motion to the equivalent one-body problem, reduced mass of the system, conservation theorems (First integrals of the motion), equations of motion for the orbit, classification of the orbits, conditions for closed orbits, stability of orbits, Kepler's laws of planetary motion. Newton's law of gravitation.

UNIT - IV - Non-linear dynamics: 13 hrs.

Classification of dynamical systems- conservative systems, integrable systems. 1D & 2D flows & their types. Logistic map, period doubling, & Feigenbaum constant (brief). Lyapunov exponent. Chaos & chaotic systems. Fractals- types & applications.
Synchronization in dynamical systems, Winfree and Kuramoto models (qualitative), phase coupled oscillators, stability and equilibrium, critical points, various applications.

References:

1. Rana N C and Joag P S, 'Classical Mechanics' (Tata McGraw Hill, 1991)
2. Sommerfeld A, 'Mechanics' (Academic Press, 1964)
3. Goldstein H, 'Classical Mechanics', II Edn. (Wiley Eastern, 1985)
4. Takwale R G and Puranik P S, 'Introduction to Classical Mechanics' (Tata
5. McGraw Hill, 1979)
6. J C Upadhyaya, 'Classical Mechanics' (Himalaya Pub House, 2014)
7. MG Calkin, 'Lagrangian and Hamiltionan Mechanics' (World Scientific, 2009)
8. M C Gutzwiller, 'Chaos in Classical and Quantum Mechanics' (Springer, 1990)
9. G L Baker and J P Gollub, 'Chaotic Dynamics - An Introduction' (CUP, 1996)
10. N Kumar, 'Deterministic Chaos' (University Press)
11. James Gleick, 'Chaos' (Penguin Books, 2011)

12. Benoit Mandelbrot, ‘The Fractal Geometry of Nature’ (WH Freeman, 1983)
13. Arvind Kumar, ‘Chaos, Fractals and Self-organization’ (NBT, 2002)
14. Pikovsky, Kurths, Rosenblum, ‘Synchronization: A Universal Concept in Nonlinear Sciences’ (CUP, 2003)
15. Steven Strogatz, ‘Nonlinear Dynamics and Chaos: With Applications to Physics, Biology, Chemistry and Engineering’ (Westview Press, 2018)

PHHT 504: ELECTRODYNAMICS

Teaching hours: 4 per week
No of credits: 4

Objectives & Skill Components:

1. Understand the concepts and problem solving methods in electrostatics and magnetostatics
2. To study the details of Maxwell's equations & learn the simple metallic waveguides and propagation of EM waves
3. Techniques for deriving and evaluating formulae for the electromagnetic fields from very general charge and current distributions
4. Formulating electromagnetic problems with the help of electromagnetic potentials, accounting gauge transformations and their use
5. Familiarize concepts of polarization of light & various techniques used in it

Course Outcomes:

CO1: Show an ability to solve problems on electricity & magnetism, electrostatics/dynamics.

CO2: Exhibit an understanding of Maxwell's equations and its applications.

CO3: Learn the concepts of metallic waveguide structure and propagation of EM wave through it.

CO4: Electromagnetic problems using electromagnetic potentials, accounting gauge transformations and their use.

CO5: A familiarity of polarization of light & techniques used in it.

UNIT - I Electrostatics and magnetostatics 13 hrs.

Review of Gauss' law and applications, Electric Potential, Poisson's equations, Work, energy in electrostatics. Laplace's equations and its solution in one, two and three dimensional problems (Cartesian coordinates). Boundary conditions and uniqueness theorem. Method of images and applications. Multipole expansion. Electric dipole field, Field inside a dielectric.

Review of Biot–Savart law, Ampere's law and applications, Magnetic vector potential, Boundary conditions. Multipole expansion of vector potential. Review of magnetization. Magnetic field inside matter.

UNIT - II Electromagnetic waves **13 hrs.**

Review of Maxwell's equations, Electromagnetic wave equations, plane wave solution of EM wave. Propagation through linear media, reflection and transmission of electromagnetic waves: plane waves in conducting media, skin depth, dispersion of electromagnetic waves in non conductors, wave guides, transmission of electromagnetic waves in rectangular wave guide.

UNIT - III Electrodynamics **13 hrs.**

Poynting Theorem and its interpretation. Scalar and vector potentials. Gauge transformations. Coulomb gauge and Lorentz gauge. Maxwell's equations in potential formulation. Jefimenko's equations. Energy and momentum in electrodynamics. Retarded potentials. Lienard-Wiechert potentials.

UNIT - IV Description of Polarized light **13 hrs.**

Polarization overview, Polarization types and states, Polarization ellipse, Poincare sphere, Stokes parameters. Electromagnetic description of polarized light: Jones & Stokes vectors. Polarization Calculus - Jones & Mueller matrices and the structure of the polarization calculi, applications (brief).

References:

1. D.J. Griffiths, 'Introduction to Electrodynamics', (PHI, 2003)
2. J.D. Jackson, 'Classical Electrodynamics' (Wiley Eastern, 2003)
3. Panofsky and Phillips, 'Classical Electricity and Magnetism', (Dover, 2005)
4. Landau and Lifshitz, 'The Classical Theory of Fields', (Pergamon, 1989)
5. B.B. Laud 'Electromagnetics' (New Age International PVT. LTD)
6. P. Lorrain and D. Corson, 'Electromagnetic field and waves' (CBS)
7. I.S Grant and W.R. Phillips 'Electromagnetism' (John Wiley and Sons)

8. Reitz J R, Milord F J, Christy R W, ‘Foundations of Electromagnetic Theory’ (Narosa Publishing House, 1990)
9. Purcell E M, `Electricity and Magnetism’, (McGraw Hill, 1985)
10. E. Hecht, Optics, 2nd edn., Addison-Wesley (1987)
11. Krauss John D, ‘Electromagnetics’, II Edn. (Tata McGraw Hill, 1973)
12. Fowles, G, Introduction to Modern Optics, (Dover, 1989)
13. Dennis Goldstein, Polarized Light, 3d Edition, (CRC Press, 2010)
14. C. Brosseau, Fundamentals of Polarized Light, (Wiley, 1998)
15. R.M.A. Azzam, and N. M. Bashara, Ellipsometry and Polarized Light, (North-Holland, Amsterdam, 1987)

PHSP 501: PHYSICS PRACTICAL I (General)

Teaching hours: 6 per week

No of credits: 3

1. Characteristics and efficiency of a GM counter.
2. Determination of energy gap of a semiconductor.
3. Susceptibility by Quinke`s method.
4. Modes of vibration of a fixed free bar.
5. To determine Young's modulus of given material.
6. Constant deviation Spectrometer
7. Ultrasonic Interferometer
8. Babinet Compensator

*** Additional experiments may be included.**

PHSP 502: PHYSICS PRACTICAL II (Electronics)

Teaching hours: 6 per week

No of credits: 3

1. UJT characteristics
2. FET characteristics
3. Fixed voltage regulator
4. Adjustable voltage regulator
5. Half adder and full adder
6. V to I and I to V converter using opamp
7. Clipper circuits
8. Clamper circuits

*** Additional experiments may be included.**

II SEMESTER

PHHT 551: MATHEMATICAL PHYSICS II AND C PROGRAMING

Teaching hours: 4 per week

No of credits: 4

Objectives & Skill Components:

1. To acquaint the students with various mathematical techniques used in Physics
2. To teach the mathematical principles involved in solving problems in Physics
3. To teach C, a very basic and important programming language
4. To improve programming skills and understand how programming can be used in Physics.

Course Outcomes:

CO1: Show advanced learning on how mathematics can be used as an effective tool in solving physical problems.

CO2: Understand and apply mathematical formulation in various branches of Physics.

CO3: Be familiar with programing and how it can be used in solving problems and doing calculations in Physics.

CO4: Exhibit skills in computational and programing application-demanding subjects.

UNIT I - Tensor analysis and calculus: 13 hrs.

Introduction - rank of a tensor. Transformation of coordinates in linear spaces - transformation law for the components of a second rank tensor. Contravariant, covariant and mixed tensors - First rank tensor, higher rank tensors, symmetric and antisymmetric tensors. Tensor algebra - outer product - contraction - inner product - quotient law. The fundamental metric tensor - associate tensors. Raising & lowering of indices. Parallel transport, affine connection & Christoffel symbols. Covariant derivative of tensors. Tensors in Physics.

UNIT II – Numerical Methods and Probability theory: 13 hrs.

Introduction and types of probability (with examples). Probability distributions- binomial, Poisson & normal; Standard, discrete & continuous distributions. Applications of probability. Numerical Techniques: Solution of a system of linear simultaneous equations:

Gauss - Jordan method, Gauss-Seidel iterative method. Curve fitting: principles of least squares method. Examples (linear and general functions). Interpolation: Definition of interpolating polynomial - finite difference operators - Newton's forward and backward interpolation formulas with examples. Numerical integration - Simpson's $1/3^{rd}$ rule - examples. Runge - Kutta method of order 4 with examples.

UNIT III - Fundamentals of problem solving, introduction to C: 13 hrs.

Prerequisites: Problem solving, phases of problem solving- definition, analysis, designing solution using Algorithm & flowcharts. Introduction to C language: Background, Structure of C program, creating & running C programs (with examples). C character set, C tokens, Identifiers, keywords, constants, variables, data types. Operators & Expressions: Arithmetic operators, Increment & Decrement, Relational, Assignment, logical, bitwise, special & conditional operators. Arithmetic & relational expressions, evaluating arithmetic expressions, precedence of operators, mathematical library functions [sqrt(), abs(), log() etc:]. Input & output in C: Reading a character [getchar() etc:], writing a character [putchar()], formatted input [scanf()], formatted output [printf()]. Control statements: Definition, simple if, if..else, if..else..if (else if ladder), nested if, switch(), programing examples. Looping statements: Definition, while loop, do while loop, for loop, jump statement, programing examples.

UNIT IV - Arrays, structures, functions & pointers: 13 hrs.

Arrays: One & two dimensional arrays, declaration, initialization, accessing array elements, programing examples. Strings: Declaration, Initialisation, string functions [strcpy(), strcat() etc:]. Structures: Definition, structure variable, accessing structure elements, array of structures, unions. Functions: Definition (syntax), function call, return type, function prototype, types of functions, local & global variables, programing examples. Pointers: Declaration of pointers, address operators, pointer arithmetic, pointers & arrays, pointers to function, array of pointers, dynamic memory allocation, programing examples.

References:

1. Chattopadhyaya P K, 'Mathematical Physics' (Wiley Eastern, 1990)
2. Joshi A W, 'Matrices & Tensors in Physics' (Wiley Eastern, 1995)
3. Synge and Schild, 'Tensor Calculus' (Dover)
4. Arfken & Weber, 'Methods of Mathematica Physics'
5. Irving J and Mullneu N, 'Mathematics in Physics and Engineering' (Academic Press, 1959)
6. Mary L Boas, 'Mathematical Methods in the Physical Sciences' (John Wiley, 1983)
7. DE Neuenschwander, 'Tensor Calculus for Physics: A Concise Guide' (John Hopkins Pub Press, 2014)
8. Mathews J and Walker R L, 'Mathematical Methods of Physics' (WA Benjamin, 1979)
9. Kernighan & Ritchie, 'C Programming Language' (Prentice Hall, 1998)
10. Mullish & Cooper, 'The Spirit of C' (Jaico, 1987)
11. Yashwant Kanetkar, 'Let Us C' (BPB Pub, 2018)
12. E. Balaguruswamy, 'ANSI C' (McGraw Hill, 2018)

PHHT 552: QUANTUM MECHANICS II

Teaching hours: 4 per week No
of credits: 4

Objectives & Skill Components:

1. To teach the laws of the micro-world, its nature and implications
2. To teach them the scope, nature and interpretation of the quantum world
3. To teach the students how quantum mechanical principles can be used in understanding the properties of matter
4. To set the stage for them to explore advanced concepts in the subject

Course Outcomes:

CO1: Appreciate the deep and profound ideas that govern the particles at the quantum scale.

CO2: Understand the nature and properties of various systems from the perspective of quantum mechanical principles.

CO3: Apply their knowledge & understanding of the subject to fathom the working of various concepts in Modern Physics.

CO4: Understand how abstract laws of quantum mechanics help us understand the nature and behavior of matter and its manifestations.

UNIT- I - Angular momentum: **13 hrs.**

Angular momentum Algebra– Angular momentum operator, commutation relations - raising and lowering operators - eigenvalues and eigenfunctions of L^2 and L_z (using ladder operators). Spin angular momentum algebra, addition of spin angular momenta, eigenvalues & eigenfunctions of S^2 & S_z, Pauli spin matrices, spinors & spinor algebra (qualitative). Addition of two angular momenta, Clebsch-Gordan coefficients.

UNIT- II- Approximation methods: **13 hrs.**

Perturbation theory for discrete levels - equations in various orders of perturbation theory - non-degenerate and degenerate cases, simple examples. Time dependent perturbation theory, Fermi golden rule, harmonic perturbation. The variational method - the hydrogen molecule - exchange interaction. The JWKB method- tunneling through a barrier, alpha decay (qualitative).

UNIT - III - Scattering theory: 13 hrs.

Laboratory and center of mass frames, differential and total scattering cross- sections, scattering amplitude; Scattering by spherically symmetric potentials; Partial wave analysis and phase shifts; Relation between sign of phase shift and the nature of the potential, Optical theorem. Applications of scattering.

UNIT- IV- Relativistic quantum mechanics & second quantization: 13 hrs. Klein-Gordon equation for a free particle, solutions and properties. Dirac equation, Dirac matrices - negative energy solution, Plane wave solutions, spin and magnetic moment of the electron, Dirac equation in a central field.

Transition from particle to field theory, Second quantization, classical field equation using action principle. Creation and annihilation operators, Fock states and number operator, commutation and anti-commutation relations and their physical implications.

References:

1. Mathews P M and Venkatesan K, 'Text Book of Quantum Mechanics' (TMH, 1976)
2. Powell J L and Crasemann B, 'Quantum Mechanics' (Addison Wesley, 1961)
3. Thankappan V K, 'Quantum Mechanics' (Wiley Eastern Ltd., 1985)
4. Schiff L I, 'Quantum Mechanics', III Edn. (McGraw Hill, 1969)
5. Ghatak A K and Lokanathan S, 'Quantum Mechanics' (Macmillan, India, 1984)
6. Merzbecher E, 'Quantum Mechanics', III Edn. (John Wiley & Sons, 1998)
7. Shankar R, 'Principles of Quantum Mechanics' (Plenum, 1980)
8. Sakurai J J, 'Modern Quantum Mechanics' (Addison-Wesley, 1994)
9. Zettili, 'Quantum Mechanics', (Wiley, 2009)
10. Cohen Tannoudji C, Diu B and Laloe F, 'Quantum Mechanics', Vol. II (John Wiley)
11. Edmonds, 'Angular Momentum in Quantum Mechanics' (Princeton Univ Press, 1960)
12. V Devanathan, 'Quantum Mechanics' (Narosa)
13. Arul Das, 'A text book of Quantum Mechanics' (New Age)
14. Sakurai J J, 'Advanced Quantum Mechanics' (Addison-Wesley, 2003)
15. Bjorken and Drell, 'Relativistic Quantum Mechanics' (McGraw Hill, 1998)

PHHT 553: NUCLEAR AND RADIATION PHYSICS

Teaching hours: 4 per week

No of credits: 4

Objectives & Skill Components:

1. To have a basic knowledge of nuclear size, shape, binding energy etc and also the
2. Characteristics of nuclear force in detail & gain knowledge about various nuclear models and potentials associated.
3. To understand and quantify the effects of nuclear radiations in the environment.
4. To understand how various types of nuclear detector woks, about Nuclear reactions, Fission and Fusion and their characteristics.
5. To understand the basic forces in nature and classification of particles, Conservations laws and quark models in detail.
6. To have hands on experience and knowledge of use of various nuclear detectors and calibration.
7. To gain the skills of protecting the public and themselves from nuclear accidents.
8. To gain the skills of removal of unwanted radiations from labs, hospitals and from environment.

Course Outcomes:

CO1: Discuss and answer about the basic constituents of the nucleus and properties of the nucleus.

CO2: Be familiar with the three processes of radioactive decay & understand the exponential behaviour of radioactive samples and know how radioactive dating works.

CO3: Understand the effects of nuclear binding energy and why it leads to nuclear fission and fusion as energy sources. Also know the difference between nuclear fission and nuclear fusion. CO4: Understand the working principles of the various nuclear detectors and how the nuclear radiations interact with matter.

CO5: Show awareness about the advantages and disadvantages of nuclear radiations.

CO6: Be aware of several practical applications of nuclear physics.

UNIT - I - General properties of nucleus and nuclear decay: 13 hrs.

General properties of nucleus: Constituents of nucleus and their properties. Mass of the nucleus-binding energy. Charge and charge distribution. Nuclear radius from mirror nuclei - spin statistics and parity. Magnetic moment of the nucleus. Quadrupole moment.

Nuclear decay: Alpha decay - quantum mechanical tunnelling. Beta decay - continuous beta ray spectrum - neutrino hypothesis. Fermi's theory of beta decay - Kurie plots and ft-values - selection rules. Detection of neutrino - non-conservation of parity in beta decay. Gamma decay - selection rules - multipolarity - Internal conversion (qualitative only)

UNIT - II - Nuclear models, nuclear reactions and reactor physics: 13 hrs.

Nuclear models: Review of nuclear models - liquid drop model - semi empirical mass formula- stability of the nuclei against beta decay - mass parabola. Shell model.

Nuclear reactions: Cross section for a nuclear reaction. 'Q' equation of a reaction in laboratory system - threshold energy for a reaction. Centre of mass system for nucleus - nucleus collision. Relation between angles and cross sections in lab and CM systems.

Reactor physics: fission chain reaction. Slowing down of neutrons - moderators. Conditions for controlled chain reactions in bare homogeneous thermal reactor. Critical size. Brief introduction of nuclear fuel cycle. Breeder Reactors.

UNIT-III - Interaction of radiation with matter, radiation detectors and ionising radiations: 13hrs.

Interaction of radiation with matter: Energy loss of heavy charged particles in matter, Bethe-Bloch formula (qualitative). Interaction of electrons with matter. Bremsstrahlung. Interaction of gamma rays with matter - photoelectric effect, Compton scattering, Klein-Nishina formula (qualitative discussion) and pair production processes.

Radiation detectors: Gas filled counters - general features - ionization chamber, proportional counter and GM counter. Scintillation detector – principle and working of NaI (Tl) gamma ray spectrometer. Semiconductor detector – principle and working of HPGe detector (qualitative). Ionising radiations and applications: Sources of ionising radiations in the environment – natural, TENORM and artificial radiation sources. Radiation quantities and units. Production of radioisotopes in reactors. Application radioisotopes and ionizing radiations.

UNIT-IV-Nuclear forces, particle physics and symmetries &conservation laws:13 hrs.

Nuclear forces: Characteristics of nuclear force. Ground state of the deuteron using square well potential - relation between range and depth of the potential. Yukawa's theory of nuclear forces and explanation of anomalous magnetic moment of the nucleus.

Elementary particle physics: Classification of fundamental forces. Elementary particles and their quantum numbers (charge, spin, Types of interactions between elementary particles, hadrons and leptons. Symmetries and conservation laws: Conservation of energy, momentum, angular momentum, charge and isospin, parity, symmetry, handedness of neutrinos, Lepton number conservation, Lepton family and three generations of neutrinos. Charge conjugation symmetry, CP violation in weak interactions, Strange particles, conservation of strangeness in strong interactions, Baryon number conservation, Gell-Mann Nishijima formula, eight-fold way (qualitative only), quark model, quark content of baryons and mesons.

References:

1. Segre E, 'Nuclei and Particles', II Edn. Benjamin, 1977.
2. Knoll G F, Radiation Detection and Measurement', II Edn. John Wiley, 1989.
3. Eisenbud M, 'Environmental Radioactivity', Academic Press, 1987.
4. Ghoshal S N, 'Atomic and Nuclear Physics', Vol. I and II, S Chand, 1994.
5. Aruthur Beiser, 'Concepts of Modern Physics', McGraw-Hill, New York 2003
6. Patel S B, 'Nuclear Physics - An Introduction' Wiley Eastern, 1991.
7. Krane K S, 'Introductory Nuclear Physics' John Wiley, 1988.
8. Roy R K and Nigam P P, 'Nuclear Physics - Theory and Experiment' Wiley Eastern Ltd., 1993
9. Singru R M, 'Experimental Nuclear Physics' Wiley Eastern, 1972.
10. Zweifel P F, 'Reactor Physics', International Student Edn. McGraw Hill, 1973.
11. Kapoor S S and Ramamurthy V S, 'Radiation Detectors' Wiley Eastern, 1986.
12. S. Hughes, 'Elementary Particles' Cambridge (1991).
13. F. Halzen and A. D. Martin, 'Quarks and Leptons', John Wiley.
14. D. Griffiths: 'Introduction to Elementary particles', John Wiley, 1987.
15. J. M. Longo, II Edition, 'Elementary Particles', McGraw-Hill, New York, 1973.
16. D. Perkins, 'Introduction to High Energy Physics'; Oxford University Press, 2005.

17. Abraham Seiden, ‘Introduction to Particle Physics’, Pearson, 2013

PHHT 554: CONDENSED MATTER PHYSICS AND ELECTRONICS

Teaching hours: 4 per week

No of credits: 4

Objectives & Skill Components:

1. To study the elements of crystal diffraction & crystal structure and applications
2. To understand the unique, novel behaviour of condensed matter systems under a wide variety of ambient conditions
3. To inculcate the knowledge towards the behaviour of combinational systems of an elements in the form of solids, quantum dots, small clusters, liquids and dense gases
4. To familiarize the concepts of superconductivity and superfluidity
5. To know the operation and application of the analog building blocks like diodes, BJT, FET etc for performing various functions
6. To design various combinational and sequential circuits & understand the basic concepts of operational amplifiers

Course Outcomes:

CO1: Demonstrate skills in Condensed Matter Physics.

CO2: Learn to use a number of approximation schemes to calculate physical properties of various condensed matter systems based on quantum mechanics.

CO3: Appreciate the physical ideas behind these approximation schemes, as well as their limitations.

UNIT-I-Elementary crystallography & X-ray diffraction: 13 hrs.

Concept of crystallography, unit cell, primitive and non-primitive, base, Bravais lattice in two and three dimension, crystal structure, coordination numbers, Miller indices, Crystal structures of NaCl, CsCl, diamond and copper. Close packing system.X-ray diffraction: Scattering of X rays by an electron, by an atom and by a crystal. Atomic scattering factor, Bragg law. Geometric structure factor. Reciprocal lattice - its properties, Ewald's sphere - its construction. Laue and powder experimental methods.

UNIT- II - Free electron theory and band theory of solids: 13 hrs.

Free electron in one dimensional potential well, three dimensional potential well, quantum state and degeneracy, density of states, Fermi Dirac Statistics and distribution with temperature, free electron theory of metals, Fermi energy above 0 K, Electronic specific heat. Electrical conductivity of metal, Relaxation time and mean free path, Wiedemann-Franz law. Failures of free electron model. Kronig-Penney mode and Effective mass. Classification of solids - metal, semiconductors, insulators. intrinsic and extrinsic semiconductors. Carrier concentration in intrinsic semiconductors (qualitative), impurity states-donor states, acceptor states. Electrical conductivity of semiconductor.

UNIT- III – Transistors and Multivibrators: 13 hrs.

BJT, JFET and MOSFET devices. Voltage divider bias. Small signal analysis of BJT and FET amplifiers in CE/CS configuration. UJT characteristics and its use in a relaxation oscillator. IC555 timer - monostable and astable multivibrators. Three pin IC voltage regulators.

UNIT -IV - Operational amplifiers and digital electronics: 13 hrs.

Operational amplifier - voltage/current feedback concepts (series and parallel). Inverting and noninverting configurations. Basic applications of opamps - comparator and Schmitt trigger. Review of Boolean algebra, Simplification of Boolean functions using K-map, Tristate devices. Combinational logic circuits – Half adder and Full adder, Decoders and encoders. Multiplexers and demultiplexers.

References

1. Kittel C, 'Introduction to Solid State Physics', IV Edn. (Wiley Eastern, 1974)
2. Omar M A, 'Elementary Solid State Physics' (Addison Wesley, 1975)
3. Dekker A J, 'Solid State Physics' (Macmillan, 1971).
4. M A Wahab " Solid State Physics" Narosa Publication, second edition 2005
5. Cullity B D and Stock S R, 'Elements of X-ray diffraction' (PHI, 2001)
6. Ashcroft F W & Mermin N D, 'Solid State Physics' (Harcourt, 1976)
7. Verma A R and Srivastava O N, 'Crystallography Applied to Solid State Physics', II Edn. (New Age, 1991)
8. Floyd T L, 'Digital Fundamentals' (Pearson Education Asia, 2002)
9. Boylestad R L & Nashelsky L, 'Electronic Devices & Circuit Theory', VIII Edn. (Prentice Hall, 2002).

10. Hayt W H, Kemmerly J E & Durbin S M, ‘Engineering Circuit Analysis’, VI Edn. (McGraw-Hill, 2002).
11. Boylestad R L, ‘Introductory Circuit Analysis’, VIII Edn. (Prentice Hall, 1997)
12. Floyd T L, ‘Electronic Devices’, V Edn. (Pearson Education Asia, 2001).
13. Gayakwad R A, ‘Opamps and Linear Integrated Circuits’, III Edn. (PHI, 1993).
14. McKelvey J P ‘Solid State and Semiconductor Physics’ (Robert E. Kreiger, 1982)
15. Singh J, ‘Semiconductor Devices’ (John Wiley, 2001)
16. Alexander C K and Sadiku M N O, ‘Fundamentals of Electric Circuits’ (McGraw Hill International Edition, 2000)
17. Donald Neamen, ‘Electronic Circuit Analysis and Design’ II Edn. (Tata McGraw Hill, 2002)
18. Sedra A & Smith K C, ‘Microelectronics’, IV Edn. (Oxford University Press, India, 1998)
19. Horenstein M N, ‘Microelectronic Circuits and Devices’, II Edn. (PHI, 1996)
20. David Bell, ‘Electronic devices and Circuits’, 5th edition (Oxford, 2008)

PHOE 551: BASIC NUCLEAR & RADIATION PHYSICS (Open Elective)

Teaching hours: 3 per week

No of credits: 3

Objectives & Skill Components:

1. To have a basic knowledge of nuclear size, shape, binding energy etc also the characteristics of nuclear force in detail.
2. To understand and quantify the effects of nuclear radiations in the environment.
3. To understand how various types of nuclear detector woks.
4. To grasp knowledge about Nuclear reactions, Fission and Fusion and their characteristics.
5. To identify and to quantify the high radiation matrices in the environment.

Course Outcomes:

CO1: Show an awareness about energy sources.

CO2: Hands on experience and knowledge of use of various nuclear detectors.

CO3: Gain the skills of protecting the public and themselves from nuclear accidents.

CO4: Skills of removal of unwanted radiations from labs, hospitals and from environment.

UNIT- I - General properties of nucleus and nuclear decay: 13 hrs.

General properties of nucleus: Constituents of nucleus and their properties. Mass of the nucleus-binding energy, Density, Charge and charge distribution. Spin statistics and parity. Magnetic moment of the nucleus. Quadrupole moment. Radioactivity & Decay law, Carbon dating, Properties of alpha, beta & gamma radiations.

UNIT- II - Nuclear detectors & Nuclear Reactor: 13 hrs.

Nuclear Fission chain reaction. Construction & Working of a nuclear reactor. Slowing down of neutrons – moderators. Nuclear fusion, Energy generation calculation in fission & fusion. Types of Radiation detectors: Gas filled counters - general features - ionization chamber, proportional counter and GM counter. Scintillation detector – principle and working of NaI (Tl) gamma ray spectrometer.

UNIT- III - Environmental Radioactivity: 13 hrs.

Sources of ionising radiations in the environment – natural, TENORM and artificial radiation sources. Radiation quantities and units. Production of radioisotopes in reactors.

Radiation shielding, Application radioisotopes and ionizing radiations. IAEA & Indian standard dose limits. ALARA principle. External and internal exposure. ICRP and AERB recommendations. Regulatory aspects of radiation protection.

References:

1. Knoll G F, Radiation Detection and Measurement', II Edn. John Wiley, 1989.
2. Eisenbud M, 'Environmental Radioactivity', Academic Press, 1987.
3. Ghoshal S N, 'Atomic and Nuclear Physics', Vol. I and II, S Chand and Company, 1994.
4. Aruthur Beiser, 'Concepts of Modern Physics', McGraw-Hill, New York 2003
5. Patel S B, 'Nuclear Physics - An Introduction' Wiley Eastern, 1991.
6. Krane K S, 'Introductory Nuclear Physics' John Wiley, 1988.
7. Training Manual for Health Physics Qualification, (Level III), (compiled by Muay C D Kathuria S P, BARC, Mumbai, 1989)

PHOE 552: Applied Solid State Physics (Open Elective)

Teaching hours: 3 per week

No of credits: 3

Objectives & Skill Components:

1. To know the details about solids and their terminologies
2. To study the different properties of solid materials
3. To familiarize with semiconductors in detail
4. To give the brief introduction to advanced technologies like nano technology and thin film technology

Course Outcomes:

CO1: Awareness about Solid State Physics.

CO2: Knowledge of materials & technological developments.

CO3: Updates about Nano science/technology & recent advances.

CO4: Familiarity with thin films & applications.

UNIT- I - Introduction to Solid State: 13 hrs.

Introduction to band theory, Types of solids and examples- Conductors, Semiconductors, Insulators and Super conductors Terminologies- Charge carriers, Mobility, Diffusion, Drift velocity. Electrical properties- conductivity and resistivity, Magnetic properties- Diamagnetic, Paramagnetic, Ferro-magnetic and anti-ferromagnetic. Optical Properties- Fluorescence and Phosphorescence.

UNIT- II - Semiconductor Physics: 13 hrs.

Semiconducting materials, energy gap, energy band diagram, significance of Fermi level, electrical and optical properties, types of semiconductors- intrinsic and extrinsic- p and n type semiconductors. Introduction to pn junction and biasing, Semiconductor devices - Light Emitting diode, Lasers and photodiodes, Applications.

UNIT- III - Nano - Science and Thin films: 13 hrs.

Scales in Nanophysics, Structure and Morphology of Nano- materials, Classification and Nomenclature, electrical and optical properties, applications.

Growth and formation of thin films, thin film deposition- physical and chemical methods, deposition parameters and their effects on film growth. Mechanical, electrical, and optical properties, applications in various fields.

References:

1. Pillai S O "Solid state Physics" (New Age International, 2018)
2. Kittel C "Introduction to Solid State Physics" (Wiley Eastern, 1974)
3. Omar M A "Elementary Solid State Physics" (Addison Wesley, 1975)
4. Dekker A J "Solid State Physics" (Macmillan, 1971).
5. Verma A R and Srivastava O N "Crystallography Applied to Solid State Physics" II Edn. (New Age, 1991)
6. P Bhattacharya "Semiconductor Optoelectronic Devices" (PHI, 2009).
7. P Poole and F J Owens "Introduction to Nanotechnology" (Wiley, 2006).
8. Yury Gogotsi Ed "Nanomaterials Hand Book" (CRC Press, Taylor & Francis Group, 2006)
9. Chopra K L and Malhotra L K (Ed) "Thin film Technology and applications" (Tata McGraw Hill, 1985)
10. Hass G and Thun R E "Physics of Thin Films" (Academic Press, 1967)
11. Chopra K L "Thin Film Phenomena" (Robert E Kreiger, 1979)
12. Goswami A "Thin film fundamentals" (New Age, 1996)
13. M. Ohring "The Materials science of thin films" (Academic Press, 1992)

PHOE 553: PHYSICS OF THE COSMOS (Open Elective)

Teaching hours: 3 per week

No of credits: 3

Objectives & Skill Components:

1. To know about basic terminologies of stars and galaxies
2. To learn the details of our system and existence of living creatures on Earth
3. To familiarize about different astronomical phenomena
4. To understand about past, present and future of the Universe

Course Outcomes:

CO1: Awareness about our Universe & its origins.

CO2: Knowledge of Astronomy & astrophysics concepts.

CO3: Understanding our solar system & the laws governing it.

UNIT- I - Stars and galaxies: 13 hrs.

Introduction to stars, Observable properties of stars- luminosity, brightness, mass, radius, temperature, color. Evolution and life cycle of stars- proto star, main sequence star, red giant, super giant, white dwarf, stellar explosion, neutron star, black hole. Binary stars, Energy sources of stars, Spectral classification of stars. Galaxies-Formation, compositions and types– Elliptical, Spiral, Irregular, study of Milky-way galaxy.

UNIT- II - Our Solar system: 13 hrs.

Astronomical units to measure distance and time, Origin and evolution of solar system- Study of the Sun, Planets, Basics of Satellite, Asteroids, Comets and Meteorites, Constellations, Solstices, Zodiac. Origin and evolution of life on Earth, Rotation and revolution of the Earth, Seasons, Full Moon and New Moon, Eclipses, Calendars in history and the recording of time.

UNIT- III - Origin and Evolution of Universe: 13 hrs.

Theories and models, stages of evolution, Steady state theory, Big bang model, Cosmic microwave background, Hubble's law and expanding universe, accelerating universe. Quasars and Pulsars. Dark matter and dark energy, Observable universe- age, future and end. Requisites for the existence of life in outer space.

References:

1. Baidyanath Basu "Introduction to Astrophysics" (PHI, 1997).
2. Michael Feilik and John Gaustad "Astronomy the Cosmic Prospective" (John Wiley & Sons Inc., 1990)
3. Feilik M, "Astronomy – The Evolving Universe" III Edn (Harper and Row, 1982)
4. D Mc Gillivray "Physics and Astronomy" (McMillan, 1987)
5. Marc L Kutner "Astronomy a physical perspective" (CUP, 2003)
6. S Hawking "A Brief history of time" (Bantam 1997)
7. S Weinberg "The first three minutes" (Basic Books 1993)
8. J Narlikar "The lighter side of gravity" (CUP)
9. V B Bhatia "Textbook of Astronomy and Astrophysics with elements of Cosmology" (CRC press, 2001)
10. K D Abhyankar "Astrophysics: Stars and Galaxies"(Universities Press, 2002)
11. B W Carroll and D A Ostlie "An Introduction to Modern Astrophysics" (Pearson)
12. F LeBlanc "An Introduction to Stellar Astrophysics" (Wiley 2010)

PHSP 551: PHYSICS PRACTICAL III (General)

Teaching hours: 6 per week

No of credits: 3

1. Study of beta ray attenuation in matter.
2. Gamma ray Spectrum of Cs-137
3. Ferroelectric Curie temperature
4. Quarter wave-plate.
5. To measure the variation of dielectric constant with temperature and verification of Curie Weiss law.
6. Study of mass attenuation using gamma source.
7. Determination of temperature sensitivity of thermocouple.
8. C programming (as many programs as possible).

*** Additional experiments may be included.**

PHSP 552: PHYSICS PRACTICAL IV (Electronics)

Teaching hours: 6 per week

No of credits: 3

1. Inverting and non-inverting amplifier
2. Astable and monostable multivibrator
3. Encoder and decoder
4. Multiplexer and demultiplexer
5. Wein bridge osscillator
6. Single stage CE amplifier
7. Binary to gray and gray to binary code converter
8. Simplification of Boolean expression using K-map and realization using NAND gates

***Additional experiments may be included.**

III SEMESTER

PHHT 601: ATOMIC AND MOLECULAR PHYSICS

Teaching hours: 4 per week

No of credits: 4

Objectives & Skill Components:

1. To study the quantum mechanical principles, thereby the spectra of hydrogen, Sodium etc.
2. To educate about X-ray spectrum and its doublet structure, theoretical descriptions over fine and hyperfine structure.
3. To impart fundamental knowledge about electron spin through both experimental and theoretical backgrounds, qualitative aspects of NMR and ESR.
4. To train about microwave, infrared, Raman, Mossbauer spectroscopy and molecular spectroscopy.

Course Outcomes:

CO1: Understand the basics concepts of Atomic/molecular Physics.

CO2: Analyze the spectra of various atoms.

CO3: Understand the structure and constitution of atoms and molecules.

UNIT - I - Spectra of single and multi electron atoms: 13 hrs.

Review of atomic models. Simple spectra of hydrogen and hydrogen like ions - energy levels, quantum numbers, electron spin, Stern-Gerlach experiment, fine structure, total angular momentum, Spin-orbit coupling, hydrogen energy levels, relativistic correction, radiation corrections, transition rates, selection rules. Spectra of two valence atom - alkali spectra, term values, doublet structure, transition and intensity rules. Spectra of alkaline earth elements, triplet structure, penetrating and non-penetrating orbitals: LS and JJ coupling. Paschen-Back effect.

UNIT - II - X-ray spectra and resonance spectroscopy: **13 hrs.**

Review of emission and absorption of X-ray spectra (critical voltage, absorption coefficient, edge, filters) regular and irregular doublet law, Auger spectra. Spin and an applied field, nuclear magnetic resonance- principle, techniques and instrumentation, structural study. Electron spin resonance spectroscopy.

UNIT- III - Microwave spectra, infrared spectra and Raman spectroscopy: 13 hrs.

Theory of rotational spectra of diatomic molecules - Experimental technique – Microwave spectrometer, structural information. Theory of vibrating rotator, vibration - rotation spectra, IR spectrometer. Application in chemical analysis (Qualitative).

Quantum theory of Raman effect. Rotational and vibrational Raman spectra. Raman spectrometer. Laser Raman studies. FT Raman spectroscopy (qualitative)

UNIT- IV - Electronic spectroscopy: 13 hrs.

Electronic spectra of diatomic molecules - coarse structure - Frank-Condon principle - rotational fine structure - formation of band head and shading of bands - determination of I, r and band origin.

Fluorescence and phosphorescence: mirror image symmetry of absorption and fluorescence bands. Basic principles of photoelectron spectra. Instrumentation. Determination of ionization potential.

Mossbauer spectroscopy: Principles of Mossbauer spectroscopy. Mossbauer spectrometer. Applications.

References:

1. Ghoshal S N, ‘Atomic and Nuclear Physics’, Vol. I and II (S Chand and Company, 1994)
2. Beiser A, `Concept of Modern Physics’ V Edn. (Tata McGraw Hill, 1997)
3. Banwell C N and E M McCash, ‘Fundamentals of Molecular Spectroscopy’ (Tata McGraw Hill, 1994)
4. White H E, ‘Introduction to Atomic Spectra’ (McGraw Hill, 1964)
5. Bransden and Joachain, ‘Physics of Atoms and Molecules’ (Prentice Hall, 2003)
6. Kuhn H G, ‘Atomic Spectra’, III Edn. (Benjamin, 1977)
7. Haken H and Wolf H C, ‘Atomic and Quantum Physics’, V Edn. (Springer-Verlag, 1997)
8. Henry Semat and John R AlBright, ‘Introduction to Atomic and Nuclear Physics’ V Edn. (Chapman and Hall, 1972)
9. Chatwall Gurdeep, ‘Spectroscopy’, III Edn. (Himalayas, 1994)
10. Robert Eisberg and R Resnick, ‘Quantum Physics of Atoms, Molecules, Solids, Nuclei and Particles’, II Edn. (John Wiley and Sons)
11. Straughan B P and Walker S, ‘Spectroscopy’, Vol. I, II and III (Chapmann and Hall, 1976)
12. Svanberg S, ‘Atomic and Molecular Spectroscopy’, II Edn. (Springer Verlag, 1992)
13. Herzberg, ‘Molecular Spectra and Molecular Structure’, Vol. I, II and III (Van Nostrand Co., 1966)

PHHT 602: THERMODYNAMICS AND STATISTICAL PHYSICS

Teaching hours: 4 per week

No of credits: 4

Objectives & Skill Components:

1. Explain the laws of thermodynamics and its applications.
2. To understand and explain the physical significance of Maxwell thermodynamic relations.
3. To learn the fundamental differences between classical and quantum statistics and learn about quantum statistical distribution laws.
4. Study important examples of ideal Bose systems and Fermi systems.
5. To understand the theoretical demonstrations of fluctuations.
6. To understand the time evolution of thermodynamic systems using non-equilibrium equation of motions.

Course Outcomes:

CO1: Discuss and answer the First Law of Thermodynamics.

CO2: Show an ability to define heat, work, thermal efficiency and the difference between various forms of energy.

CO3: Exhibit skills to identify and describe energy exchange processes (in terms of various forms of energy, heat and work).

CO4: Apply the steady-flow energy equation or the First Law of Thermodynamics to a system of thermodynamic components (heaters, coolers, pumps, turbines, pistons, etc.) to estimate required balances of heat, work and energy flow.

CO5: Explain the concepts of path dependence/independence and reversibility/irreversibility of various thermodynamic processes, to represent these in terms of changes in thermodynamic state.

UNIT- I - Thermodynamics: 13 hrs.

Concept of entropy - principle of entropy increase - entropy and disorder. Enthalpy –

Helmholtz and Gibb's functions. Maxwell's relations - Tads equations - energy equations - Heat capacity equations - heat capacity at constant pressure and volume. Phase space and ensembles – Liouville's theorem, probability - thermal equilibrium.

UNIT - II - Classical statistics: **13 hrs.**

Boltzmann distribution, calculation of velocities - average and r.m.s velocities Gibbs' paradox, Sackur - Tetrode equation, partition functions - translational partition function, vibrational, rotational and electronic partition functions. Boltzmann equipartition theorems. Application to specific heats.

UNIT -III - Quantum statistics: **13 hrs.**

Bosons and Fermions - Bose-Einstein and Fermi-Dirac distributions - degenerate Fermi and Bose gases - Bose-Einstein condensation - Planck's law of black-body radiation.

Liquid helium - Lambda transition.

Fluctuations - Fluctuations in canonical, grand canonical and microcanonical ensembles. Number fluctuations in quantum gases.

UNIT -IV - Brownian motion: **13 hrs.**

Langevin equation for random motion, Random walk problem. Diffusion and Einstein relation for mobility. Time dependence of fluctuations: power spectrum of fluctuations, persistence and correlation of fluctuations. Wiener - Khinchin theorem, Johnson noise and Nyquist theorem. Shot noise, Fokker-Planck equation.

References:

1. Zemansky M W and Dittman R H, 'Heat and Thermodynamics', VII Edn. (McGraw Hill International Edn., 1999)
2. Gopal E S R, 'Statistical Mechanics and Properties of Matter' (Macmillan, 1976)
3. Agarwal B K and Melvine Eisner, 'Statistical Mechanics' (Wiley Eastern Ltd., 1991)
4. Kittel C and Kroemer H, 'Thermal Physics', II Edn. (CBS Pub., 1980)
5. Chandler D, 'Introduction to Modern Statistical Mechanics' (Oxford University Press, 1987)
6. Reichl L E, 'A Modern Course in Statistical Physics' (University of Texas Press, 1980)
7. Landau and Lifshitz, 'Statistical Physics' (Oxford, Pergamon, 1980)
8. Gupta M C, 'Statistical Thermodynamics' (New Age, 1995)
9. Reif F, 'Fundamentals of Statistical and Thermal Physics' (McGraw Hill, 1965)
10. Garg, Bansal and Ghosh, 'Thermal Physics: with Kinetic Theory, Thermodynamics and Statistical Mechanics' (McGraw Hill, 2007)

PHST 601: CONDENSED MATTER PHYSICS I

Teaching hours: 4 per week

No of credits: 4

Objectives & Skill Components:

1. To familiarize the basic concepts about crystal structures, symmetries
2. To focus on the principle of elastic and thermal properties of crystals
3. To study the dielectric and ferroelectric nature of crystals
4. To understand the plasmonic properties of the solids through different theories & relations

Course Outcomes:

CO1: Show an understanding of basic concepts required to understand the nature of bulk materials.

CO2: Be oriented towards a new specified subject.

CO3: Be familiar with the principle and applications of the solid state.

UNIT - I – Crystallography: 13 hrs.

Symmetries elements, translations vectors – screw axes and glide plane symmetries. Space groups – illustrations, Concept of point groups, Influence of symmetry on physical properties, derivation of equivalent point positions (with examples from triclinic and monoclinic systems), experimental determination of space group. Disordered solid structure - Amorphous solid, quasi crystal and liquid crystal.

UNIT - II - Elastic properties and thermal properties: 13 hrs.

Analysis of elastic strains and stresses, Elastic compliance and stiffness constants, Energy density, Cubic crystals and isotropic solids, Elastic waves in cubic crystals, Experimental determination of elastic constants.

Thermal properties of insulators, Normal modes of diatomic lattice, Phonon momentum, Inelastic scattering of photons and neutrons by phonons, Thermal expansion, Lattice thermal conductivity - normal and Umklapp processes.

UNIT - III - Dielectric and ferroelectric properties of solids: 13 hrs.

Dielectric : Polarization, Dielectric susceptibility, Dielectric constant, Complex dielectric constant, Dielectric loss and loss angle. Local electric field, Polarizability, Clausius - Mossotti relation, Electronic, ionic and dipolar polarizability. Frequency dependent dielectric function, Dipole orientation in solids, Langevin function, Debye relaxation time. Ferroelectrics: Basic properties of ferroelectrics, Classification, Barium titanate, Thermodynamics of paraelectric - ferroelectric transition, ferroelectric domain, Polarization catastrophe, Antiferroelectricity. Pyroelectric, piezoelectric and ferroelectric crystals. Piezoelectricity and its applications.

UNIT - IV - Optical properties of solids: 13 hrs.

Dielectric function of the free electron gas, Plasma optics, Dispersion relation for electromagnetic waves, Transverse optical modes in a plasma, Transparency of alkalis in the ultraviolet, Longitudinal plasma oscillations, Plasmons and their measurement; Electrostatic screening, Screened Coulomb potential, Mott metal-insulator transition, Screening and phonons in metals; Optical reflectance, Kramers-Kronig relations, Electronic inter band transitions- direct and indirect transition, Absorption in insulators; Polaritons; One-phonon absorption; Optical properties of metals, skin effect and anomalous skin effect. Excitons: Frenkel and Mott-Wannier excitons.

References:

1. Ashcroft N W and Mermin N D, 'Solid State Physics' (Harcourt, 1976)
2. Kittel C, 'Introduction to Solid State Physics', IV Edn. (Wiley Eastern, 1974), VII Edn. (John Wiley, 1995)
3. Wahab M A, 'Solid State Physics", III Edn. (Narosa Publishing House Pvt. Ltd, 2015)
4. Srivastava J P, 'Element of Solid State Physics' IV Edn (Prentice Hall India Learning Pvt Ltd, 2014)
5. Cullity B D and Stock S R 'Elements of X ray Diffraction', III Edn. (Prentice Hall, 2001)
6. Woolfson M M, 'An Introduction to X-ray Crystallography' (Cambridge-Vikas, 1970)
7. Buerger M J, 'X-ray Crystallography' (John Wiley, 1942)
8. Brusch P : 'Phonons : Theory & Experiments', Vol I, II & III (Springer Verlag, 1987)
9. Ibach H and Luth H, 'Solid State Physics', II Edn. (Springer, 1996)
10. Ziman J M, 'Principles of the Theory of Solids', II Edn. (Vikas Publ., 1979).

PHST 602: CONDENSED MATTER PHYSICS II

Teaching hours: 4 per week

No of credits: 4

Objectives & Skill Components:

1. To understand band structures in crystals using NFE and TBA theories.
2. To understand transport properties and its application to the solids.
3. To understand the principle and applications of semiconductor devices.

Course Outcomes:

CO1: Demonstrate the familiarity with the types of extrinsic semiconductors, theory and mathematical aspects related to extrinsic semiconductors.

CO2: Show an understanding of the formation of pn junction and also junction theory.

CO3: Be skilled in low dimensional semiconductors and their applications.

CO4: Be aware of different semiconductor devices.

CO5: Understand the advanced semiconducting materials.

UNIT - I - Band theory of solids: 13 hrs.

Bloch theorem. Nearly Free electron approximation. Tight binding approximation. Applications of the tight binding method to cubic crystals: width of energy bands, the effective mass of electrons in a simple cubic lattice based on tight binding approximation. The shape of constant surfaces and Fermi surfaces, Density of states curve for the simple cubic lattice. Construction of Brillouin zones for a two-dimensional square lattice. General expression for density of states function and calculation of density of states curve for the simple cubic lattice based on tight binding approximation. Overlapping of energy bands and Jones explanation of structural phase transitions in binary alloys.

Quantization of electron orbits in magnetic fields. Experimental methods in Fermi surface studies - de Haas – van Alphven effect in Fermi surface determination.

UNIT - II - Transport properties: 13 hrs.

Boltzmann transport equation. Electrical conductivity. Thermal conductivity, Thermoelectric effects and thermopower power. Scattering of electrons. Temperature variation of electrical resistance. Linearized Boltzmann transport equation. AC conductivity of metals. Hall effect, High field effects and magnetoresistance. Cyclotron resonance. Plasma frequency and plasmons.

UNIT- III - Semiconductors I: 13 hrs.

Extrinsic semiconductors. Impurity ionization energy Fermi energy - variation with impurity density and temperature. Electrical conductivity. Cyclotron resonance in semiconductors.

Excess carriers. Quasi-Fermi levels. Recombination of carriers. Continuity equation. P-N junctions: Abrupt and graded junctions. Junction space charge, electric field, electric potential and width. Rectification process. Derivation of ideal current-voltage characteristics. P-N junction capacitance.

Metal semiconductor contacts : Formation of rectifying/ Schottky contacts, Depletion layer, Interface states and Fermi level pinning. Current transport processes, Derivation of ideal current voltage characteristics of schottky diodes based on thermionic emission theory. Capacitance of Schottky diodes. Ohmic contacts.

UNIT - IV - Semiconductors II: 13 hrs.

Low-dimensional Semiconductor structures: Basics of semiconductor alloys and heterostructures. Basics of Fundamentals of quantum wells, quantum wires and quantum dots. Two-dimensional electron gas in uniform electric and magnetic field –Landau levels. Quantum Hall and Shubnikov de Haas effect (qualitative). Degenerate semiconductor. Esaki diode.

Amorphous semiconductor: Introduction, Band structures and density of states. Structure of amorphous semiconductors and structural models. Electrical and Optical properties.

Organic Semiconductors: Introduction, and doping, electrical and optical properties. Organic semiconductor Devices.

Optolectronic devices (Qualitative aspects only): Photo detectors, Photoconductor, P-N and P-I-N Photodiodes, Heterojunction Photodiodes, Avalanche photodiodes (APDs), Phototransitors. Solar cells. Light emitting diodes.

References:

1. Mckelvey J P, ‘Solid State and Semiconductor Physics’ (Robert E Kreiger, 1982)
2. Ziman J M, ‘Principles of the Theory of Solids’ II Edn. (Vikas Publ., 1979)
3. S. M, Sze and K. K. Ng, ‘Physics of Semiconductor Devices’ (3rd Edn, Wiley 2006).
4. Wahab M A, ‘Solid State Physics”, III Edn. (Narosa Publishing House Pvt. Ltd, 2015)
5. Pillai S O, ‘Solid state Physics’, (New Age International, 2018)
6. Ibach H and Luth H, ‘Solid State Physics’ II Edn. (Springer, 1996)
7. B. G. Streetman and S. Banerjee, ‘Solid State Electronic Devices’ 4th to 6th Edition (PHI)
8. P. Bhattacharya, ‘Semiconductor Optoelectronic Devices, 2nd Edition (PHI, 2009).
9. J. H. Davies, ‘The Physics of Low-diemnsional Semiconductors: An Introduction, (Cambidge University Press, 1998).
10. M. Li, ‘Modern Semiconductor Quantum Physics’ (World Scientific, 1994).
11. J. Singh and K. Shimakawa, Advances in Amorphous Semiconductors
12. D. D. Sharma, G. Kotliar and Y. Tokura, ‘Advances in Condensed Matter Science’, Vol.5 (Taylor & Francsis)
13. S. R. Elliot, ‘Physics of Amorphous Materials, 2nd Ed. (Longman Scientific & Technical, London).

PHST 603: ELECTRONICS I

Teaching hours: 4 per week

No of credits: 4

Objectives & Skill Components:

1. To introduce the basic concepts of microprocessors.
2. To teach the programming techniques of microprocessor 8085 using assembly language.
3. To familiarize students with the concepts of interfacing devices with microprocessors.

Course Outcomes:

CO1: Be familiar with the basic concepts of microprocessors.

CO2: Exhibit programming skills of microprocessor 8085 using assembly language.

CO3: Show familiarity with the concepts of interfacing with microprocessors.

UNIT - I - Structure of computer systems and 8085 architecture: 13 hrs.

Review of binary and hexadecimal number system - negative number representation.
Basic structure of computer systems – Microprocessors, Single chip micro controller system. Introduction to CPU architecture and interfacing the devices. Instruction classification, instruction, data format and storage.
8085 architecture - register organization – Memory, input and output devices, Example of microcomputer system. 8085 instruction set – classification.
Instruction cycle, machine cycle, timing diagram.

UNIT - II - Programming with 8085: 13 hrs.

8085 instructions – data transfer, arithmetic, logic and branch operations. Writing assembly language programs. Programming techniques with additional instructions. Counters and time delays.
Stack and subroutines, conditional CALL and RETURN instructions.
Interrupts – 8085 interrupts – vectored interrupts, software interrupt instructions .

UNIT- III - Peripherals: 13 hrs.

8155, 8255, 8254, 8259A, DMA 8237.Interfacing data converters – ADC and DAC
Introduction to 16 bit microprocessors. 8086/8088

UNIT- IV - Microcontrollers: **13 hrs.**

CISC and RISC processors, Von Neumann & Harvard architectures. Comparison of microprocessor and microcontroller, Types of microcontrollers, Microcontroller architectures, Features of 8051, 8051 microcontroller register set, Instruction set and programming. Interfacing applications of 8051.

References:

1. Gaonkar R S, 'Microprocessor architecture, programming and applications with the 8085', IV Edn. (Penram International, 2000)
2. Hall D V, 'Microprocessors and interfacing, programming and hardware', II Edn. (Tata McGraw Hill, 1992)
3. Mazidi M A & Mazidi J G, 'The 8051 Microcontroller', (Pearson Education Asia, 2001).
4. Ayala Kenneth J, 'The 8051 microcontroller' (Penram International, 1996)
5. Ayala K J, 'The 8086 Microprocessor', (Penram International, 1995)

PHST 604: ELECTRONICS II

Teaching hours: 4 per week

No of credits: 4

Objectives & Skill Components:

1. To study the different types of analog and digital communication.
2. To study wired and wireless communication.
3. To study waveguides and principle of antennas.
4. To study microwave devices and their applications.

Course Outcomes:

CO1: Show an awareness about basic terminologies of radio communication system.

CO2: Be familiar with the different types of modulation techniques used in radio communication system.

CO3: Show an increased learning about radio transmitter and receiver in detail.

CO4: Be familiar with different types of pulse communication system and digital communication system.

UNIT - I - Transmission lines: 13 hrs.

Distributed parameters, types of transmission lines, calculation of line parameters. Inductance and capacitance of parallel round conductors, coaxial cables. Voltage, current and impedance relations. Characteristic impedance, reflection coefficient, propagation constant. Line distortion and attenuation. Line parameters at high frequencies, Line termination. Standing wave ratio. Quarter and half wavelength lines. Impedance matching, quarter wave transformer, stub matching. Smith chart and its applications.

Unit - II - Waveguides and antenna: 13 hrs.

Basic concepts, guided waves between parallel planes. TE & TM waves. Rectangular wave guides. Qualitative treatment of circular wave guides, comparison with coaxial cable, wave guide coupling. Matching and attenuation, cavity resonators. Directional couplers, Electromagnetic radiation, elementary doublet, current and voltage distribution, resonant and non resonant antennas, radiation pattern, antenna gain, effective radiated power, antenna resistance, bandwidth, beam width, polarisation, grounded and ungrounded antennas. Effect of antenna height. Microwave antennas (qualitative).

UNIT - III - Analog modulation and demodulation: 13 hrs.

Need for modulation, AM generation, power and bandwidth calculations. FM generation, power and bandwidth calculation. AM & FM transmitters (block diagram).

Demodulation: receivers for AM & FM signals. AVC & AFC circuits. Pre-emphasis and De-emphasis. Digital modulation: sampling theorem, PAM, PDM, PPM system comparison. PCM technique. ASK, FSK, PSK & QPSK systems.

UNIT - IV - Microwave devices and satellite communication: 13 hrs.

Multicavity klystron, reflex klystron, parametric amplifiers, Gunn diode, Microwave transistors & FETs.

Communication subsystems, description of the communication system transponders, spacecraft antennas, frequency reuse antennas, multiple access schemes, frequency division multiple access, time division multiple access, code division multiple access. Tracking geostationary satellites. Examples of satellite communication systems - IRS & INSAT series.

References:

1. Kennedy and Davis, ‘Electronic Communication Systems’, IV Edn. (Tata McGraw Hill, 1993)
2. Ryder J D, ‘Networks, Lines and Fields’ II Edn. (PHI, 1997)
3. Tomasi Wayne, ‘Electronic Communication Systems’, (Pearson Education Asia, 2001)
4. Dennis Roddy and John Coolen, ‘Electronic Communications’, IV Edn. (PHI, 1995)
5. Kraus & Fleisch, ‘Electromagnetics with Applications’, V Edn. (McGraw Hill, 1999)
6. Taub & Schilling, ‘Principles of Communication System’, II Edn. (McGraw Hill, ISE, 1986)
7. Liao S Y, ‘Microwave Devices and Circuits’, III Edn. (PHI)
8. Roddy D, ‘Satellite Communications’, III Edn. (McGraw Hill, 2001)
9. Giridhar, ‘Microwaves & Radar’

10. Pratt, Bostian & Allnutt, ‘Satellite Communications’, II Edn. (Wiley)

PHOE 601: PHYSICS OF THE MICRO WORLD (Open Elective)

Teaching hours: 3 per week

No of credits: 3

Objectives & Skill Components:

1. To introduce non-Physics students to the concepts of Modern Physics
2. To familiarize the seemingly bizarre ideas of Quantum Physics
3. To give students the basics of Quantum Mechanics which might find applications in their respective subjects
4. To discuss some of the important implications and consequences of the subject

Course Outcomes:

CO1: Awareness about Physics at the sub-atomic scale.

CO2: Familiarity with the concepts of Quantum Mechanics.

CO3: Appreciation of paradigm altering ideas in Modern Physics.

UNIT - I - Introduction & Historical Background: 13 hrs.

Review of Newton & Huygens' theories of light, experimental vindications, Young's double slit experiment & implications; Photoelectric & Compton effects, Einstein's ideas. Brief review of blackbody radiation & spectra, Planck's theory and applications. Brief overview of Modern Physics.

UNIT - II - Basics of Quantum Mechanics: 13 hrs.

Ideas of duality in matter/radiation, de Broglie's theory and experimental verifications. Schrodinger's equation, wave function and Born's interpretation. Properties of wave function, normalization. Simple applications and numerical recipes. Postulates of Quantum Mechanics. Brief discussion of mathematical structure of Quantum Mechanics.

UNIT - III - Interpretation & Applications: 13 hrs.

Revisiting the double slit experiment- its implications & interpretation, role of observer, Copenhagen interpretation. Uncertainty principle, its meaning and implications. Nature of observation & reality in Quantum Mechanics, Schrodinger's cat, alternate interpretations and limitations. Retrospective discussion of a few applications of Quantum Mechanics.

References:

1. Feynman Lectures on Physics, Vol 3, Quantum Mechanics – RP Feynman, RB Leighton, ML Sands (Addison Wesley, 2000)
2. Introduction to Quantum Mechanics – DJ Griffiths (CUP, 2018)
3. Quantum Physics - S Gasiorowicz (Wiley India, 2007)
4. Quantum Mechanics: The Theoretical Minimum - Leonard Susskind and Art Friedman (Penguin Paperbacks, 2015)
5. Concepts of Modern Physics – Arthur Beiser (McGraw Hill, 2003)
6. Modern Physics – Kenneth Krane (Wiley, 2012)
7. How to Teach Physics to Your Dog - Chad Orzel (Scribner, 2010)
8. The Quantum World: Quantum Physics for Everyone - Kenneth W. Ford (Harvard University Press, 2005)
9. Quantum: Einstein, Bohr & the Great Debate About Nature of Reality - Manjit Kumar (WW Norton, 2008)
10. Mr. Tompkins in Paperback - George Gamow (CUP, 2012)
11. Speakable and Unspeakable in Quantum Mechanics - JS Bell & A Aspect (CUP, 2004)
12. In Search of Schrodinger's Cat – John Gribbin (Random House, 2011)

PHOE 602: EVERYDAY ELECTRONICS (Open Elective)

Teaching hours: 3 per week

No of credits: 3

Objectives & Skill Components:

1. To introduce students to the basic concepts of electricity & electronics
2. To familiarize the ideas of current & voltage
3. To familiarize the electronic components and circuits
4. To provide students with the concepts needed for electronic communication

Course Outcomes:

CO1: Awareness about various Electronics concepts.

CO2: Familiarity with the working & functioning of various electronic devices.

CO3: Appreciation of electronic technology.

UNIT - I - Electronics Terminology: 13 hrs.

Introduction to electronic signals: Analog, digital, alternating current, direct current, electromagnetic signals: RF, AF and microwave. Measuring parameters and instruments: Voltage, Current and Power; Voltmeter, Ammeter, Multimeter. Measurement of current, voltage and power using multimeter.

UNIT - II - Electronic Circuits: 13 hrs.

Circuit components: Passive components: resistor, capacitor, inductor and transformer. Active components: diode, transistor and integrated circuits. Circuit theory: Ohm’s Law. Applications: Rectifier, regulator and amplifier.

UNIT - III - Electricals and Electronics: 13 hrs.

Power electronics: Single, two and three phases, switches and plugs. Fuse: Short circuit, electric shock, earthing. Electronic communication: Message, transmitter, channel, receiver, antenna, tuning. Different electrical and electronics home appliances.

References:

1. V K Mehta, 'Principles of Electronics', XI Edn. (S Chand Publications)
2. S L Gupta & V. Kumar, 'Hand Book of Electronics', XXXXIV Edn. (Pragathi Prakashan Publications)
3. B L Theraja, Fundamentals of Electrical Engineering and Electronics', XXVII Edn. (S Chand Publications)
4. Boylestad R L & Nashelsky L, 'Electronic Devices & Circuit Theory', VIII Edn. (Prentice Hall, 2002).
5. Sedra A & Smith K C, 'Microelectronics', IV Edn. (Oxford University Press, India, 1998)
6. Horenstein M N, 'Microelectronic Circuits and Devices', II Edn. (PHI, 1996)
7. David Bell, 'Electronic devices and Circuits', 5^{th} edition (Oxford, 2008)
8. Floyd T L, 'Electronic Devices', V Edn. (Pearson Education Asia, 2001)

PHOE 603: PHYSICS OF SIGHT AND SOUND (Open Elective)

Teaching hours: 3 per week

No of credits: 3

Objectives & Skill Components:

1. To introduce students to the basic concepts of waves & energy
2. To familiarize the ideas of light & sound
3. To provide students with the concepts needed to understand waves, light etc.
4. To give students concepts which might find applications in their respective subjects

Course Outcomes:

CO1: Awareness about various concepts used in waves & oscillations.

CO2: Familiarity with the working principles of acoustics & optics.

CO3: Appreciation of ideas & concepts used in Sound & Light.

UNIT - I - Introduction to waves: 13 hrs.

Introduction to waves & wave motion, examples & properties of waves. Types of waves & their generation. Important terms & concepts related to waves, graphical representation of waves. Description of wave motion & its types (harmonic & damped). Types & conditions for damping. Resonance, Waves in a medium. Applications.

UNIT - II - Basics of Acoustics: 13 hrs.

Introduction to sound waves, Propagation of sound in different media. Acoustic energy and intensity, different units and scales of sound, wave equation and its solution (1D), properties. Reflection of sound waves, Echo & Doppler effect, reverberation, Sabine's formula & applications. Beats, fundamental note, overtones & harmonics, brief mention of musical notes & instruments.

UNIT - III - Light & Optics: 13 hrs.

Nature & properties of light, reflection & refraction, conditions & simple applications. Interference & double slit experiment, diffraction of light & applications. Polarization of light, types & applications. Total internal reflection, Brewster's law and applications. Dispersion of light, electromagnetic spectrum and introduction to different spectra.

References:

1. Fundamentals of Physics – Resnick, Halliday & Walker (Wiley, 2010)

2. University Physics with Modern Physics - H Young & R Freedman (Pearson International, 2015)

3. Feynman Lectures on Physics, Vol 1&2 – RP Feynman, RB Leighton, ML Sands (Addison Wesley, 2000)

4. Waves: Berkeley Physics Course, Vol 3 – F Crawford (Tata McGraw-Hill, 2007)

5. The Physics of Vibrations and Waves – HJ Pain (JohnWiley)

6. Vibrations and Waves - AP French (CBS, 2003)

7. The Physics of Waves and Oscillations – NK Bajaj (McGraw Hill)

8. Optics - E Hecht (Pearson, 2005)

9. Introduction to Optics - Ajoy Ghatak (McGraw Hill, 2016)

10. A Textbook of Optics - N.Subrahmanyam & Brij Lal (S.Chand Publishing)

12. Principles of Optics - Max Born & Emil Wolf (PergamonPress)

13. Geometrical and Physical Optics - RS Longhurst (Orient Blackswan)

PHSP 601: CONDENSED MATTER PHYSICS - PRACTICAL I

Teaching hours: 6 per week

No. of credits: 3

1. Characteristic of solar cell
2. Characteristics of LED and LASER diode
3. Characteristics of Photodiode
4. Dielectric Constants of solids and liquids
5. Electron Spin Resonance
6. XRD simulation
7. Thermoluminescence
8. Optical constants of metals

***Additional experiments may be included.**

PHSP 602: CONDENSED MATTER PHYSICS - PRACTICAL II

Teaching hours: 6 per week

No. of credits: 3

1. Determination of Stefan Boltzmann Constant
2. Determination of energy gap of a semiconductor using p-n junction diode
3. B H curve
4. Lattice dynamics
5. Determination of Planck's constant using LED
6. Hall effect
7. PN junction characteristics
8. Thermoelectric effect

***Additional experiments may be included.**

PHSP 603: ELECTRONICS –PRACTICAL I

Teaching hours: 6 per week **No. of credits: 3**

1. Two stage CS amplifier
2. Cascode amplifier
3. Complimentary symmetry push - pull power amplifier
4. 3bit asynchronous up/down counter
5. Full wave precision rectifier with equal resisters
6. Frequency multiplication using PLL565
7. Phase shifter using opamp
8. R-2R ladder type DAC
9. Instrumentation amplifier
10. 8085 programming examples

***Additional experiments may be included.**

PHSP 604: ELECTRONICS –PRACTICAL II

Teaching hours: 6 per week

No. of credits: 3

1. Amplitude modulation
2. Demodulating AM voltage
3. PLL565 – Frequency synthesis
4. Frequency modulation using IC 8038
5. Pulse width modulation
6. Frequency shift keying using PLL565
7. Pre-emphasis and de-emphasis
8. Wave generators
9. Voltage controlled oscillator.
10. Active filters

***Additional experiments may be included.**

IV SEMESTER

PHHT 651: LASER PHYSICS, VACUUM TECHNIQUES AND CRYOGENICS

Teaching hours: 4 per week

No. of credits: 4

Objectives & Skill Components:

1. To learn how vacuum can be created using different methods and sustained
2. To understand different types of vacuum systems in different range and vacuum gauges
3. To learn about applications of Vacuum technology in thin film deposition
4. To understand the definition, production & applications of lasers
5. To understand different methods of production of cryogenic temperature, cryo engines.

Course Outcomes:

CO1: Be familiar with difference between low level source, linear optics and laser source, nonlinear source.

CO2: Be aware of research work in NLO.

CO3: Show familiarity with the application of laser in NLO.

CO4: Show an understanding of low temperature gas production methods, low temperature measuring equipment like thermocouple, RTD, gas thermometer.

UNIT I - Lasers: 13 hrs.

Lasers - introduction - directionality, intensity, monochromaticity, coherence. Einstein coefficients - stimulated emission. Basic principles of lasers - the threshold condition - laser pumping. Some specific laser systems - Neodymium lasers - He-Ne laser - ion lasers - CO2 laser - Semiconductor lasers - dye lasers - chemical lasers – X-ray lasers, free electron laser. Applications.

UNIT -II - Holography and non-linear optics: 13 hrs.

Principle of holography - some distinguishing characteristics of holographs - practical applications of holography.

Non-linear optics: harmonic generation - second harmonic generation - phase matching - third harmonic generation Z scan technique - optical mixing - parametric generation of light - self focussing of light. Electro optic effect.

Multiquantum photoelectric effect - two photon processes - multiphoton processes - three photon processes.

UNIT- III - Vacuum techniques: 13 hrs.

Units of vacuum - vacuum spectrum (ranges - low - medium - high - ultra high). Applications - freeze drying - vacuum coating - industrial applications. Conductance of pipes - pumping speed - throughput - pumpdown time.

Vapour pressure - vacuum gauges and the relevant range of vacuum - Pirani gauge - thermocouple gauge - Pennning gauge. Vacuum pumps - rotary vane pump (pumping speed and ultimate pressure) - oil diffusion pump - baffle and trap - cryopump - turbomolecular pump – sorption pump. Vacuum feedthroughs - vacuum valves (diaphragm valve, slide valve, ball valve).

UNIT- IV - Cryogenic techniques: 13 hrs.

Overview of the techniques of liquefaction of gases (Nitrogen, Hydrogen and Helium). Gas purification - Stirling cycle refrigeration and liquefaction of helium.

Properties of cryogenic fluids (Nitrogen and Helium 4). Storage and transfer of cryogenic fluids: Dewars for nitrogen and helium. Liquid level indicators and gauges.

Measurement of temperature: Resistance thermometers (metal, alloys & semiconductors). Thermocouple - (Au + Fe) vs chromel. Magnetic thermometer.

Cooling by evaporation of helium 4 and helium 3 - cooling by adiabatic demagnetisation. Cryostats for low temperature experiments. Applications of cryogenics: Hydrogen bubble chamber - Rocket propulsion system - superconducting magnets.

References:

1. Silfvast W T, ‘Laser Fundamentals’ (Cambridge University Press, 1998)
2. Laud B B, ‘Lasers & Nonlinear Optics’ (Wiley Eastern, 1985)
3. Ghatak A K and Thyagarajan, ‘Optical Electronics’ (Cambridge University Press 1991)
4. Mills D L, ‘Nonlinear Optics – Basic Concepts’ (Narosa Publishing, 1991)
5. Wilks J and Betts D S, `An Introduction to Liquid Helium’ (Oxford University Press, 1987)
6. Shen Y R, ‘The Principles of Nonlinear Optics’ (John Wiley, 1984)
7. Boyd R W, ‘Nonlinear Optics’ (Academic Press, 1992)
8. Zernike F & Midwinter, ‘Applied Nonlinear Optics’ (Wiley, 1973)
9. Oshea D C, Callen W R & Rhodes W T, ‘Introduction to Lasers & Their Applications’ (Addison Wesley, 1977)
10. Roth A, `Vacuum Technology’, II Edn. (North Holland, 1982)
11. Barron R F, `Cryogenic Systems’ II Edn. (Oxford University Press, 1985)
12. Harris N S, `Modern Vacuum Practice’ (McGraw Hill, 1989)
13. O’Hanlon J F, `A User’s Guide to Vacuum Technology’ (John Wiley, 1980)
14. West C D, `Principles and Applications of Stirling Engines’ (Van Nostrand Reinhold, 1986)

PHHT 652: ASTROPHYSICS AND RELATIVITY

Teaching hours: 4 per week

No. of credits: 4

Objectives & Skill Components:

1. To study the concepts of Astronomy, origin & theories about the Universe
2. To learn the details of stellar evolution, stellar classification and galaxies
3. To study basic concepts of Special & General relativity, its uses & applications

Course Outcomes:

CO1: Be familiar with the details of stellar evolution, stellar classification and galaxies.

CO2: Know about big bang theory, evolution of Universe and origin of life on Earth.

CO3: Exhibit the knowledge about concepts of relativity and relativistic dynamics.

CO4: Familiarity with the structure of space-time and gravity.

UNIT- I- Astronomy: 13 hrs.

Introduction, constellations, solstices, equinoxes, zodiac, temperature of stars and their classification, visible and invisible astronomy. Asteroids, Comets and Meteorites. Doppler effect. Hubble's law. Origin and evolution of solar system. Apparent and absolute magnitudes of stars. Measurement of stellar distances – method of heliocentric parallax, statistical parallax method, apparent luminosity method, spectroscopic parallax method. Variable star distances. Nova distances.

UNIT - II - Astrophysics: 13 hrs.

Energy generation in stars, contents of Milky-way galaxy, Hertzsprung – Russel diagram – it's uses. Evolution of stars – star birth, evolution to, on and off the main sequence, evolution to the end. White dwarfs, neutron stars, stellar explosions – nova, pulsars, black holes, binary X-ray systems and quasars. Cosmological models – steady state and Big-Bang models. Evolution of Universe. Origin of life on earth.

UNIT - III - Special theory of relativity: 13 hrs.

Review of Newtonian Mechanics, Galilean transformation equations & consequences.

Aether & Measurement of speed of light – Michelson Morley experiment & its results. Inertial & non-inertial frames, Postulates of relativity, Lorentz transformation, length contraction, time dilation, space-time continuum, Minkowski's world - 4 dimensional line element. 4 velocity, 4 acceleration, 4 momentum and 4 force. Relativistic force law and dynamics of single particle. Equivalence of mass and energy. Maxwell's equations in covariant form (Brief).

UNIT - IV - General theory of relativity: 13 hrs.

Review of tensor calculus and Riemannian geometry, Geodesies, The curvature tensor, Riemannian metric & space, Riemann tensor. Einstein's equations: The Principle of Equivalence and general covariance, inertial & gravitational mass, Eotvas' experiment. Gravitation as space time curvature, Gravitational field equations of Einstein and its Newtonian limits. The Schwarzschild metric. Experimental validation of General relativity. Singularity and black holes (brief).

References:

1. Introduction to Astrophysics 'Baidyanath Basu' (PHI, 1997).
2. Michael Feilik and John Gaustad 'Astronomy the Cosmic Prospective' (John Wiley & Sons, Inc., 1990)
3. Marc L Kutner "Astronomy a physical perspective (Cambridge University Press 2003)
4. Resnik R, 'Introduction to Special Relativity' (Wiley Eastern, 1972)
5. Rindler W, 'Introduction to Special Relativity' (Oxford University Press)
6. P G Bergman , Theory of Relativity, Asian Publishers
7. Schutz B F, 'A First Course in General Relativity' (Cambridge University Press, 1985)
8. Srivastava , 'General Relativity and Cosmology' (PHI)
9. J Hartle, 'Gravitation: An Introduction To Einstein'S General Relativity' (Addison Wesley, 2003)
10. Feilik M, 'Astronomy – the Evolving Universe' (Harper and Row, 1982)
11. Moller C, Theory of Relativity II Edn. (Claredon Press, 1972)
12. D Mc Gillivray 'Physics and Astronomy' (McMillan, 1987)
13. Ray d'Inverno, 'Introducing Einstein's Relativity' (Oxford University Press, 1992)
14. Adler R, Bazin M & Schiffer M, 'Introduction to General Relativity', II Edn. (McGraw Hill, 1975)
15. Spacetime and Geometry: An Introduction to General Relativity - Sean M. Carroll (CUP, 2019)
16. General Relativity - Robert Wald (University of Chicago Press, 2010)

PHST 651: CONDENSED MATTER PHYSICS III

Teaching hours: 4 per week

No. of credits: 4

Objectives & Skill Components:

1. To impart fundamental an advanced knowledge about magnetism and associated materials
2. To understand the theoretical and experimental aspects of ESR and NMR
3. To study nano-materials, its properties and their structure-property relationship, general and advanced synthesis methods, various material characterization techniques and material applications
4. Understanding various principles and theories about magnetic materials & their applications

Course Outcomes:

CO1: Exhibit a working knowledge of concepts in Condensed Matter Physics concepts.

CO2: Show the skills in understanding of experimental techniques of the subject.

CO3: Familiarity with recent advances in the subject.

UNIT - I - Ferromagnetism: 13 hrs.

Classical molecular field theory. Heisenberg exchange interaction. Ising model. Spin waves and magnons. Bloch $T^{3/2}$ law. Band theory of ferromagnetism. Magnetisation of ferromagnets. Crystalline anisotropy. Domains. Bloch wall. Ferromagnetic materials. Neutron diffraction - magnetic structure.

UNIT - II - Antiferro and ferrimagnetism: 13 hrs.

Molecular field theory. Indirect exchange interaction. Antiferromagnetic materials. Helimagnetism. Molecular field theory for ferrimagnetic materials. Spinels and garnets. Magnetic bubbles.

UNIT - III - Paramagnetic relaxation and magnetic resonance: 13 hrs.

Paramagnetic relaxation: Susceptibility in alternating magnetic field. Thermodynamic theory of Casimir and Dupre for spin lattice relaxation. Spin - spin relaxation.

Electron paramagnetic resonance: Introduction. Phenomenological theory of resonance. line width, hyperfine structure. Spectra of transition group ions. ESR spectrometer.

Nuclear magnetic resonance (NMR): Elements of the theory of NMR – Bloch equations. Solutions of the Bloch equations weak RF filed. NMR line shape and width. Resonance in non-metallic solids. Influence of nuclear motion on NMR line width. Chemical shift. Quadrupole effect in NMR. NMR Experimental aspects. Ferromagnetic resonance. Introduction, shape effects in ferromagnetic resonance.

UNIT - IV - Nanomaterials and nanostructures: 13 hrs.

Introduction. Physical properties of the materials at the nanoscale: Melting points and lattice constants. Mechanical properties. Optical properties- Surface plasmon resonance, Quantum size effects in optical absorption and photoluminescence. EIectrical conductivity-Surface scattering, Quantum transport. Bottom-Up and Top-Down Approaches of nanomaterials synthesis.

Zero-Dimensional nanostructures - nanoparticles: Introduction, Nanoparticles through homogeneous nucleation. Nanoparticles through Heterogeneous Nucleation.

One-Dimensional Nanostructures:- Nanowires and Nanorods: Intoruduction, Synthesis of one-dimensional nanostructures.

Fabrication of nanoscale structures with physical techniques : Lithographic techniques, Nanomanipulation and nanolithography, Soft lithography, Self-assembly of nanoparticles or nanowires.

A brief introduction on carbon fullerenes, nanotubes and graphene.

References:

1. A. H. Morrish, ‘The Physical Principles of Magnetism’ (Wiley-Blackwell, 2001)
2. G. Cao, Nanostructures & Nanomaterials: Synthesis, Properties & Applications’ (World Scientific, 2011).
3. J. Crangle, ‘Solid State Magnetism’ (Edmond-Arnold, 1991).
4. C. Kittel, ‘Introduction to Solid State Physics’, 4^{th} to 8^{th} Edition.
5. D. J. Dekker, ‘Solid State Physics’ (Macmillan India)
6. P Slichter ‘Principles of Magnetic Resonance’ (Springer, 1996).
7. P. Poole and F. J. Owens, ‘Introduction to Nanotechnology’ (Wiley, 2006).
8. Ibach H & Luth H ‘Solid State Physics’ II Edn. (Springer, 2000)
9. K. Yosida, ‘The Theory of Magnetism’ (Springer, 1998).
10. Ashcroft N W and Mermin N D, ‘Solid State Physics’ (Harcourt, 1976)
11. Rogalski M S and Palmer S B ‘Solid State Physics’ (Gordon & Breach, 2000)
12. Yury Gogotsi Ed., ‘Nanomaterials Hand Book’ (CRC Press, Taylor & Francis Group, 2006)

PHST 652: CONDENSED MATTER PHYSICS IV

Teaching hours: 4 per week

No. of credits: 4

Objectives & Skill Components:

1. To study the various crystal defects
2. To impart in-depth knowledge of basics and applications of thin film technology
3. To familiarize students with superconductivity, polymers and liquid crystals
4. To acquire skills in synthesizing and characterizing thin films

Course Outcomes:

CO1: Show an increased knowledge in research work in crystals& crystal growth,

CO2: Be familiar with different types of crystal defects and its application in electrical conductivity in battery.

CO3: Show an awareness about special verity of the materials, polymers and their applications.

CO4: Know about Liquid Crystal Displays and their applications.

UNIT- I - Crystal defects: 13 hrs.

Imperfections in crystals: classification of defects in crystals - point defects - their energy of formation - diffusion - ionic conductivity in pure and doped halides - colour centers – polorons, excitons. Dislocations - Burger's vector. Observation of dislocation - dislocations and crystal growth. Planar defects. Luminescence in solids: Thermoluminescence – Electroluminescence.

UNIT - II - Thin films: 13 hrs.

Introduction. Physical vapour deposition methods – Evaporation – general considerations. Evaporation methods. Sputtering – Sputtering methods. Chemical vapour deposition (CVD) methods – Typical chemical reactions. Reaction kinetics, Transport phenomena, CVD methods. Atomic Layer Deposition (ALD). Liquid-based growth methods.

Nucleation, growth and structure of thin films: Nucleation- condensation process, theories of nucleation, nucleation modes. Growth Process. Aspects of physical structure of thin films. Nano composites. Epiaxial growth of thin films.

Characterization of Thin Films: Thickness measurement. Structural and morphological characterization, chemical and optical characterization, electrical characterization.
Brief Applications of thin films.

UNIT - III - Superconductivity: **13 hrs.**

Thermodynamics of superconductivity. Coherence length. A brief overview of BCS theory of superconductivity: Instability of Fermi Sea and Cooper pairs, BCS ground state, Consequences of the BCS theory and comparison with experimental results. Magnetic flux quantization in a superconducting ring.
Single particle and Coper-pair -Josephson tunnelling. AC and DC Josephson effects, Macroscopic Quantum Interference, Superconducting Quantum Interference Devices (SQUIDS). DC and AC SQUIDs. Applications of SQUIDs.
High T_C superconductors: Discovery YBCO, Important families of high temperature superconductors.

UNIT - IV - Polymers and liquid crystals: **13 hrs.**

Polymers : Introduction. Classification. Molecular weight. Configuration. Determination of molecular weight. Polymer processing. Crystallanity. Conducting polymers. Applications.
Liquid crystals : Classification. Structure and texture. Orientational and translational order. Mechanical, optical, magnetic and electrical properties. Liquid crystal displays.

References:

1. Ibach H and Luth H ‘Solid State Physics’, II Edn. (Springer, 2000)
2. Chopra K L and Malhotra L K (Ed) ‘Thin film Technology and applications’ (Tata McGraw Hill, 1985)
3. Tinkham M ‘Introduction to Superconductivity’ II Edn. (McGraw Hill, 1996)
4. Gowarikar V R, Vishwanathan N V and Shridhar J, ‘Polymer Science’ (Wiley Eastern, 1986)
5. Chandrasekhar S, ‘Liquid Crystals’, II Edn. (Cambridge, 1992)
6. Hass G and Thun R E, ‘Physics of Thin Films’, Vol. IV (Academic Press, 1967)
7. Chopra K L ‘Thin Film Phenomena’ (Robert E Kreiger, 1979)
8. Goswami A, ‘Thin film fundamentals’ (New Age, 1996)
9. M. Ohring: The Materials science of thin films, (Academic Press, 1992, 2nd Ed.

10. Chiaken P and Lubensky T C, ‘Principles of Condensed Matter Physics’ (Cambridge, 1995)
11. Rogalski M S and Palmer S B ‘Solid State Physics’ (Gordon & Breach, 2000)

PHST 653: ELECTRONICS III

Teaching hours: 4 per week

No. of credits: 4

Objectives & Skill Components:

1. To study the development of printed circuit boards.
2. To know the linear and nonlinear applications of operational amplifiers.
3. To study the power devices and importance of power amplifiers.
4. To study programmable logic devices.

Course Outcomes:

CO1: Be able to develop printed circuit boards.

CO2: Show familiarity with linear and nonlinear applications of operational amplifiers.

CO3: Show familiarity with power devices and importance of power amplifiers.

UNIT - I – Printed circuit board design and IC fabrication techniques: 13hrs.

Printed circuit board design techniques: Layout scale, grid system, board types. Materials and aids, documentation – circuit diagram, component list, layout sketch, mechanical drawing. PCB parameters – resistance, inductance, capacitance. Component spacing, conductor spacing, cooling requirements and packing density. PCB manufacturing – copper clad laminates, Types of laminates and properties of laminates. Mentions of plating. Etching – different etchants, pollution minimisation. Multilayer boards. Soldering techniques – wave soldering.

IC fabrication technologies: Wafer preparation- chemical vapour deposition - diffusion - ion implantation-photolithography. Fabrication of resistors, capacitors, BJT & MOS devices.

UNIT - II - Characteristics and simple applications of special semiconductor devices: 13 hrs.

Schottky barrier diode - varactor diode - Tunnel diode - Photo diode – LED - Thermistor - solar cell, IGBT. CMOS inverter.

Amplifiers: cascade amplifiers - cascode amplifiers. Darlington connection. Power amplifiers - Class A, Class B & Class AB amplifiers. Power transistor heat sinking.

Silicon controlled switch, DIAC and TRIAC applications.

UNIT - III - Operational amplifiers: 13 hrs.

Voltage References (5V) - voltage level detector - Comparator IC 311 - Phase shifter - precision rectifier - peak detector - instrumentation amplifier. Active filters - 40 dB/decade roll off (low pass, high pass & band pass).

Precision triangle & square wave generator - IC AD630. Voltage to frequency and frequency to voltage converter. Analog multiplier - IC AD633 - squaring a dc voltage and doubling the frequency of ac. Frequency multiplier using phase locked loop IC565.

UNIT - IV - Sequential circuits and data converters: 13 hrs.

Review of Latches, Flip-flops, Counters and Registers, Sample and hold circuit, Digital to analog conversion -Types. Analog to digital conversion- Types. Digital to analog converter AD558. Analog to digital conversion - Successive approximation ADC - microprocessor compatible ADC AD670. Programmable logic devices - Programmable array logic PAL 16L8 - Generic array logic GAL 22V10.

References:

1. Walter C Bosshart, ‘Printed Circuit Boards - Design and Technology’ (Tata McGraw Hill, 1983)
2. Coughlin R F & Driscoll F F, ‘Operational Amplifiers and Linear Integrated Circuits’, VI Edn. (Pearson Education Asia, 2002).
3. Gayakwad R A, ‘Opamps and Linear Integrated Circuits’ IV Edn. (PHI, 2002)
4. Floyd T L, ‘Digital Fundamentals’, VII Edn. (Pearson Education Asia, 2002)
5. Henry W Ott, ‘Noise Reduction Techniques in Electronic Systems’ (John Wiley, 1989)
6. Jaspreet Singh, ‘Semiconductor Devices’ (McGraw Hill, 1994)
7. Boylestad R & Nashelsky L, ‘Electronic Devices and Circuit Theory’ VIII Edn. (PHI, 2002)
8. Neamen Donald, ‘Electronic Circuit Analysis and Design’ II Edn. (Tata McGraw Hill, 2002)
9. Floyd T L, ‘Electronic Devices’, V Edn. (Pearson Education Asia, 2001)
10. Franco S, ‘Designing with Operational Amplifiers and Analog Integrated Circuits’, III Edn. (McGraw Hill, 2001)
11. Tocci R J, ‘Digital Systems, Principles and Applications’, VIII Edn. (Pearson Education Asia, 2001)
12. Wakerly, ‘Digital design’, III Edn. (Expanded), (Pearson Education Asia, 2002)
13. Winzer J, ‘Linear integrated circuits’ (Saunders College Publ., 1992).

14. Millman and Halkias, “Integrated Electronics” (McGraw Hill).

15. David Bell, ‘Electronic devices and Circuits’, 5th edition (Oxford, 2008)

PHST 654: ELECTRONICS IV

Teaching hours: 4 per week

No. of credits: 4

Objectives & Skill Components:

1. To familiarize students with the working principle of optical fibres.
2. To teach the recent developments in optic fibre communication.
3. To orient the students towards the advanced concepts in signal processing.

Course Outcomes:

CO1: Be familiar with the basic structure and working principle of Optical Fiber Cable.

CO2: Know about different types of optical sources and optical detectors.

CO3: Be familiar with the basic power budget designing techniques used in OFC communication system.

UNIT- I - Optic fibre communication: 13 hrs.

Relevance and advantages of OFC, description of a simple OFC link, types of optical fibres, Ray theory of light guiding in optical fibres, modal analysis of optical fibres (qualitative), single mode fibres, graded index fibres, signal attenuation and dispersion in optical fibres. Optical source to fibre coupling (basics), optical fibre splicing and connectors (basics).

UNIT - II - Optical sources & detectors: 13 hrs.

Structure and working of a laser diode. Single mode lasers (basic). Output characteristics and modulation characteristics of LED & laser diodes.

Optical detectors: Structure and working of PIN diode and avalanche photodiode. Quantum efficiency, responsivity and response speed of photodiodes. Noise characteristics of photo diodes. Optical receiver systems, digital and analog transmission systems. Power and rise time budget analysis.

UNIT- III - Digital signal processing: 13 hrs.

Classification of signals, properties of discrete time signals and systems – linearity, stability and causality concepts. LTI systems – convolution. Fourier analysis of discrete time signals and systems. Sampling and modulation principles, aliasing effect, sampling theorem. Z-transforms - transfer function – properties of Z-transform, pole-zero plot, inverse Z-transforms (partial fraction method and long division method.

UNIT - IV - Discrete fourier transform (DFT) and IDFT: 13 hrs.

Circular convolution – properties of DFT, FFT algorithms (Radix 2) – flow charts.
Discrete system realization: IIR structures - direct form I & II, CSOS and PSOS structures.
Finite impulse response (FIR) structures: direct form and cascade structures. IIR filter design: qualitative analysis of impulse invariance and bilinear transformation methods.
FIR filters - linear phase FIR design using window functions, Gibbs' phenomenon.

References:

1. Keiser G, 'Optical Fibre Communications', III Edn. (McGraw Hill ISE, 2000)
2. Senior J M, 'Optical Fibre Communication', II Edn. (PHI, 1996)
3. A Nagoor Kani, 'Digital Signal Processing', II Edn. (McGraw Hill Pub.)
4. Ghatak A & Thyagarajan K, 'Introduction to Fibre Optics' (Cambridge University Press, 1999)
5. Haykin S, 'Signals and Systems' (John Wiley, 1998)
6. Oppenheim A V, Willsky A S and Nawab S H, 'Signals and Systems', II Edn. (PHI, 1997)
7. Proakis J G and Manolakis D G, 'Digital Signal Processing', III Edn., (PHI, 1992)
8. Salivahanan S, Vallavaraj A & Gannapriya G, 'Digital Signal Processing', (Tata McGraw Hill, 2001)
9. Mitra S K, 'Digital Signal Processing' (Tata McGraw Hill, 1998)
10. Oppenheim A V and Schafer R W, 'Discrete-Time Signal Processing' (PHI, 1992)
11. Roman Kuc, 'Introduction to Digital Signal Processing' (McGraw Hill, 1988).
12. Joseph C. Palais, 'Fiber Optic Communications', 5th Edition (Pearson)

PHPD 651: PROJECT WORK (with Viva)

Teaching hours: 8 per week

No. of credits: 4

PHC1: RESEARCH METHODOLOGY AND COMPUTATIONAL TECHNIQUES

(CERTIFICATE COURSE)

No of hours: 21+21 = 42 hrs (Offered in III and IV semesters respectively)

Objectives & Skill components:

1. To equip rigour & independence of thought, foster individual judgment and skill in the application of research methods
2. To develop skills required in writing research proposals, reports, journal articles, dissertation & thesis
3. To introduce the concept at the heart of every research project - the research problem, & discuss what a "researchable" problem is
4. To strengthen computational skills & techniques
5. To familiarize usage of resources & tools like MATLAB, LATEX, Origin etc.

Course Outcomes:

CO1: Familiarity with research methods, analysis & techniques in doing research.

CO2: Know about different types of sources and articles, doing literature review etc.

CO3: Usage of various computational resources & techniques in scientific research.

UNIT- I - Research Methodology & The Research Problem: 07 hrs.

Meaning & definitions of Research, Objectives & motivation in Research, general characteristics & criteria of good research; Types of research. Scientific thinking, defining a research problem, selecting the problem, sources & evaluation of a problem. Hypothesis, designing experiments, analysis, results & models.

UNIT - II - Manuscript writing and Document Preparation: 07 hrs.

Scientific writing: Structure and components of research paper, types of reports, research papers, thesis, research project reports, citations, impact factor, different styles for science journals. Conducting & reporting literature review, report structure - writing abstract, introduction, review of literature, result, and conclusions. Concepts of bibliography and references, reference managers.

UNIT - III - Articles, Journals & Publication: 07 hrs.

Different types of articles & journals (Original Research, Review Articles, Short reports or Letters, Case Studies, Methodologies). Volume & issue. Primary & secondary literature, peer review & popular/news articles, arxiv, preprints & accessing journals, journal indexing, DOI, authorship & acknowledgements. ISBN, ISSN & Conference Proceedings. Role of journals & importance of scientific publications, ethical issues & copyright, IPR & Industry Institute collaborations. Steps involved in publication of papers. Writing projects for funding – different funding agencies/schemes, major & minor research projects.

UNIT - IV – Computational Techniques: 21 hrs.

MATLAB: Introduction, Basic features, Mathematical functions, Basic plotting, Matrix generation, Array operations, Solving linear equations, Introduction to programming in MATLAB, Control flow and operators.

Origin: Introduction, The Origin Workspace, Multi-sheet Workbooks, Managing Data and Metadata. Importing Data from different sources, Working with Excel and Origin, Basic Data Manipulation, Creating and Customizing Graphs, Custom Graph Templates and Themes, Publishing Graphs, Basic Data Analysis.

LATEX: Introduction, Document structure, Typesetting text, Packages, Classes, Tables and Figures, Equations, Inserting references, Presentations using beamer.

References:

1. Research Methods in Education - Cohen L., Lawrence M., & Morrison K. (OUP, 2005)

2. Research Methodology - Best and Kahn (PHI)

3. The Scientific Endeavor: Methodology & Perspectives of Sciences - Jeffrey A Lee (Pearson India, 2010)

4. How to Write & Publish - RA Day and Barbara Gastel (Cambridge, 2006)

5. The Craft of Scientific Writing - Michael Alley (Springer, 1996)

6. Research Methodology: Research and techniques - Kothari C. R. (New Age International, 1980)

7. Research Methodology: A step-by-step guide for beginners - Kumar R. (TJ International Ltd, Padstow, Corwall, 2011)

8. Practical Research: Planning and design - Leedy P. D. (McMillan Pub. Co., 1980)

9. Fundamental of Research Methodology and Statistics - Singh, Y. K. (New International, 2006)

10. Your Research Project: A step-by-step guide for the first-time researcher - Wallinman N. (Sage Publications, 2006)

11. http:// cloud.originlab.com/pdfs/Origin91_Documentation/English/Origin_9.1_

User_Guide_E.pdf

12. https://www.originlab.com/pdfs/Origin2017_Documentation/English/Origin_User_Guide_2017_E.pdf

13. https://www.originlab.com/pdfs/Origin2017_Documentation/English/Origin_Tutorial_2017_E.pdf

14. Desmond J. Higham & Nicholas J. Higham, 'MATLAB Guide', III Edn. (Society for Industrial and Applied Mathematics)

15. Tobin A. Driscoll, 'Learning MATLAB', 2009 Edn. (Society for Industrial and Applied Mathematics)

16. David F. Griffiths & Desmond J. Higham, 'Learning Latex', 2016 Edn. (Society for Industrial and Applied Mathematics)

17. https://www.latex-project.org/help/documentation/

18. http://www.docs.is.ed.ac.uk/skills/documents/3722/3722-2014.pdf

19. https://www.tug.org/twg/mactex/tutorials/ltxprimer-1.0.pdf

SDM COLLEGE (AUTONOMOUS), UJIRE M Sc DEGREE PROGRAMME IN PHYSICS

QUESTION PAPER PATTERN FOR HARDCORE AND SOFTCORE (4 CREDITS)

PATTERN

The examination marks for hardcore (4 credits), softcore (3/4 credits) and open elective (3 credits) theory course is 70.

Each hard/soft theory course syllabus is divided into 4 units. The semester ending examination will be aimed at testing the student's proficiency and understanding in every unit of the syllabus. The blue print for the question paper pattern is as follows: Each question paper will consists of 5 parts I, II, III, IV and V. Each of the parts from Part I to Part IV carries 15 marks. Each Part consists of two full questions and one full question from each part is to be chosen. Part V is compulsory which consists of seven questions and five questions are to be answered. Part V carries 10 marks. The model question paper is given below.

M.Sc. Degree Examination

PHYSICS

PHHT/PHST XXX: Model paper (CBCS) (Hardcore/Softcore (4 credits))

Time: 3 Hours **Max. Marks: 70**

Note: Answer any **four** questions choosing **one** from each of the Parts **I** to **IV** and **five** questions in Part **V.**

PART - I

1a)

b)

c) (15)

OR

2 a)

b)

c) (15)

PART - II

3 a)

b)

c) (15)

OR

4 a)

b)

c) (15)

PART - III

5 a)

b)

c) (15)

OR

6 a)

b)

c) (15)

PART - IV

7 a)

b)

c) (15)

OR

8 a)

b)

c) (15)

PART V

9 Answer **any five** of the following: (5x2 =10)

a)

b)

c)

d)

e)

f)

g)

QUESTION PAPER PATTERN FOR OPEN ELECTIVE

PATTERN

Each open elective theory course syllabus is divided into 3 units. The semester ending examination will be aimed at testing the student's proficiency and understanding in every unit of the syllabus. The blue print for the question paper pattern is as follows: Each question paper will consists of 4 parts I, II, III and IV. Each of the parts from Part I to Part III carries 20 marks. Each Part consists of two full questions and one full question from each part is to be chosen. Part IV is compulsory which consists of seven questions and five questions are to be answered. Part IV carries 10 marks. The model question paper is given below.

M.Sc. Degree Examination, PHYSICS
PHOE XXX: Model paper
(CBCS) (Open elective)

Time: 3 Hours **Max. Marks: 70**

Note: Answer any **three** questions choosing **one** from each of the Parts **I** to **III** and **five** questions in Part I**V.**

PART – I

1 a)
b)
c) (20)

OR

2 a)
b)
c) (20)

PART - II

3 a)
b)
c) (20)

OR

4 a)

b)

c) (20)

PART - III

5 a)

b)

c) (20)

OR

6 a)

b)

c) (20)

PART IV

9 Answer **any five** of the following: (5x2 =10)

a)

b)

c)

d)

e)

f)

g)

PRACTICAL EXAMINATION: Semester end practical examination for each practical course in all the semesters is for 100 marks. Maximum marks for final practical examination shall be 70. The marks shall be awarded in the examination based on the procedure, conduct of the practicals, results and viva related to the practicals. Remaining 30 marks is for internal assessment.

CERTIFICATE COURSE EXAMINATION:

A certificate shall be given on successful completion of the course based on continuous evaluation (seminars, assignments and overall involvement of the student).

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