ಮಂಗಳೂರು ವಿಶ್ವವಿದ್ಯಾನಿಲಯ
MANGALORE UNIVERSITY
(Accredited by NAAC with 'A' Grade)

ಕ್ರಮಾಂಕ/ No. : MU/ACC/CR 18/2020-21/A2

ಕುಲಸಚಿವರ ಕಛೇರಿ
ಮಂಗಳಗಂಗೋತ್ರಿ – 574 199
Office of the Registrar
Mangalagangothri – 574 199
ದಿನಾಂಕ/Date:20.11.2020

NOTIFICATION

Sub: Revised syllabus of M.Sc. Physics programme.
Ref: Academic Council approval vide agenda
No.:ಎಸಿಸಿ:ಶೈ.ಸಾ.ಸ.1:44 (2020–21) dtd 06.10.2020.

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The revised syllabus of M.Sc. Physics programme which is approved by the Academic Council at its meeting held on 06.10.2020 is hereby notified for implementation with effect from the academic year 2020-21.

Copy of the Syllabus shall be downloaded from the University Website (www.mangaloreuniversity.ac.in)

REGISTRAR

To,

1. The Chairman, Dept. of Physics, Mangalore University, Mangalagangothri.
2. The Chairman, P.G. BOS in Physics, Mangalore University, Mangalagangothri.
3. The Registrar (Evaluation), Mangalore University, Mangalagangothri.
4. The Superintendent (ACC), O/o the Registrar, Mangalore University.
5. The Asst. Registrar (ACC), O/o the Registrar, Mangalore University.
6. The Director, DUIMS, Mangalore University – with a request to publish in the website.
7. Guard File.

MANGALORE UNIVERSITY

DEPARTMENT OF POST GRADUATE STUDIES & RESEARCH IN PHYSICS
MANGALORE UNIVERSITY
MANGALAGANGOTHRI 574199

SYLLABUS FOR CHOICE BASED CREDIT SYSTEM FOR THE TWO YEAR (FOUR SEMESTER) POST GRADUATE DEGREE PROGRAMME IN M.Sc. (PHYSICS)

FOR THE DEGREE
OF
MASTER OF SCIENCE
IN PHYSICS

DEPARTMENT OF PHYSICS
MANGALAGANGOTHRI

MANGALORE UNIVERSITY
DEPARTMENT OF PHYSICS

REGULATIONS AND SCHEME OF EXAMINATIONS FOR TWO – YEAR (FOUR SEMESTERS) MASTER'S DEGREE COURSE IN PHYSICS FOR CHOICE BASED CREDIT SYSTEM

Title of the Programme

The programme shall be called Master of Science in Physics – M Sc (Physics)

Programme Learning Outcome (PLO)

PLO1. **Physics knowledge:** The MSc physics programme create a comprehensive scientific knowledge, and this knowledge will help to understand, explain, and to solve advanced scientific problems.
PLO2. **Problem analysis:** Identify, formulated and analyse advanced problems in physics.
PLO3. **Design/development of solutions:** Design solutions for complex problems using the knowledge of physics.
PLO4. **Conduct investigations of complex problems**: Use methodology and knowledge of physics to design innovative experiments, analyse and interpret the data.
PLO5. **Modern tool usage**: To apply modern experimental and theoretical tools of physics along with modern computation technology to predict and model advanced problems in physics.
PLO6. **Physics and society**: Apply the knowledge of physics to critically assess and analyse the problems of society.
PLO7. **Environment and sustainability**: To ensure that the development in physics maintains and sustains the environment.
PLO8. **Ethics**: Apply and commit to professional ethics of physics.
PLO9. **Communication**: Effectively communicate the activities of physics to physics community and to society through effective presentation, reports and documentation.
PLO10**. Project management:** To demonstrate the knowledge of physics and to apply it to multidisciplinary environments.
PLO11. **Life-long learning:** Recognize the need to engage in independent and life-long learning in the context of scientific/ technological change.

Programme Specific outcome (PSO)

PSO1
On completion of the course the students will be able to explain the wide range of physical phenomena with underlying principles with respect to condensed matter physics, nuclear and particle physics both scientifically and in the wider perspective to the community.

PSO2
The current status of physics and associated developments can be understood and explained thoroughly.

PSO3
Show the ability to solve physics related problems and demonstrate the physics phenomenon through experiments.

PSO4
Well qualified to clear national level and state level qualifying examinations for research and teaching at graduate and postgraduate levels.

PSO5
The knowledge acquired during the course would also make the students able to pursue their higher studies as well as to use their knowledge to get into R & D and industrial sector.

PSO6
The knowledge acquired during the course will make the students to think, innovate and help to make original contribution to the domain knowledge.

PSO7
The inter-disciplinary knowledge gained during the course will help the student to understand a problem in a better way and would be able to address the problem with a complete understanding.

Eligibility for Admission

The candidates who have passed the three year B Sc degree examination of Mangalore University or any other University considered equivalent there to, with Physics as major / optional subject/special subject are eligible for the programme provided they have studied Mathematics as major/optional/special/minor/subsidiary subject for at least two years and secured a minimum of 45% (40% for SC/ST/Category-I candidates) marks in Physics and Mathematics.

Course Pattern Highlights

i) The M.Sc (Physics) PG Programme shall comprise "Core" and "Elective" subjects. The "Core" subjects shall further consists of "Hard" and "Soft" papers. Hard core papers shall have 4 credits; soft core paper shall have 3or 4 credits. Open electives shall have 3 credits. Total credit for the programme shall be 92 including open electives.

ii) Core papers are related to the discipline of the M.Sc (Physics) programme. Hard core papers are compulsorily studied by a student as a core requirement to complete the programme of M.Sc (Physics). Soft core papers are elective but are related to the discipline of the programme. Two open elective papers of 3 credits each shall be offered in the II and III semester by the department. Open elective will be chosen from an unrelated programme within the faculty or across the faculty.

iii) Total credit for the M.Sc (Physics) programme is 92. Out of the total 92 credits of the programme, the hard core (H) shall make up 60.47 % of the total credits; soft core (S) is 39.53 % while the open electives (OE) will have a fixed 6 credits (3 credits - 2 papers).

DEPARTMENT OF POSTGRADUATE STUDIES AND RESEARCH IN PHYSICS
PROPOSED CBCS COURSE STRUCTURE

Semester	Theory (Hard Core)/ Soft core	Credits	Practicals Soft/ Hard	Credits	Theory (Elective) Soft/hard	Credits	Theory (Open Elective)	Credits	Projects Hard/soft	Credits	Total credits
I	4 H	4x4=16	2 S	6	-	-	-	-	-	-	22
II	4 H	4x4=16	2 S	6	-	-	1	3	-	-	25
III	2 H	2x4=8	2 S	6	2 S	2x4=8	1	3	-	-	25
IV	2 H	2x4=8	-	-	2 S	2x4=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:

Hard core credits with %	Soft core 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	92

NOTE:

FIRST SEMESTER: The first semester consists of four theory papers which are hard core (4 hours per week for each paper and shall carry 4 credits for each paper) and two practicals (soft core 6 hours per week for each practical paper and each practical paper carries 3 credits). The duration of the lab is 3 hours. The students have to come twice a week for each of the practical paper.

SECOND SEMESTER: The second semester consists of four theory papers which are hard core (4 hours per week for each paper and shall carry 4 credits for each of the papers) and two practical (soft core 6 hours per week for each practical paper and each practical paper 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 paper. In addition there shall be an open elective paper to be opted by the student from other departments. The open elective course is a soft core paper (3 hours per week and shall carry 3 credits).

THIRD SEMESTER: The third semester consists of four theory papers, two general theory papers and two elective papers. The elective papers are offered in each of the three specializations, condensed matter physics, electronics and nuclear physics. The two general papers are hard core (4 hours per week and shall carry 4 credits). The two elective papers offered in each of the three specializations are soft core papers (4 hours per week and shall carry 4 credits). The two practical papers for each of the above mentioned specialization are soft core papers (6 hours per week and shall carry 3 credits for each of the practical paper). The duration of the lab is 3 hours for each practical. The students have to come twice a week for each of the practical papers. In addition there is an open elective course to be opted by the student from other departments. The open elective is a soft core paper (3 hours per week and shall carry 3 credits).

FOURTH SEMESTER: The fourth semester consists of four theory papers, two general theory papers and two elective papers. The elective papers are offered in each of the three specializations, condensed matter physics, electronics and nuclear physics. The two general papers are hard core (4 hours per week and shall carry 4 credits). The two elective papers offered in each of the three specializations are soft core papers (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 hard core having 8 hours per week with 4 credits.

MANGALORE UNIVERSITY

M Sc (Physics) Scheme of Examination, Marks and Credits

SEMESTER	Theory/practicals	Exam. hours	Marks end Semester + Internal assessment	Credits	Total
I Semester	4 Theory papers (hard core)	3 hrs each	70 + 30* each	4 x 4 = 16	400
	Two practicals (soft core)	3 hrs each	70 + 30* each	2 x 3 = 6	200
II Semester	4 Theory papers(hard core)	3 hrs each	70 + 30* each	4 x 4 = 16	400
	Two practicals (soft core) One open elective (theory)	3 hrs each 3 hrs	70 + 30* each 70 + 30* each	2 x 3= 6 1x3 =3	200 100
III Semester	4 Theory Papers i) Two hard core (4 credits) ii) Two soft core (4 credits)	3 hrs each	70 + 30* each	2x 4 = 8 2 x 4 = 8	400
	Two practicals (soft core) One open elective (theory)	3 hrs each 3 hrs	70 + 30* each 70 + 30* each	2 x 3 = 6 1 x3=3	200 100
IV Semester	4 Theory Papers i) Two hard core (4 credits) ii) Two soft core (4 credits)	3 hrs each	70 + 30* each	2 x 4 = 8 2 x 4= 8	400
	Project (hard core)		70 + 30*	1 x 4 = 4	100
			Grand Total	92	2500

*Internal Assessment

NOTE:

BASIS FOR INTERNAL ASSESSMENT:

Internal assessment marks in theory papers shall be based on two tests in each theory paper and the total internal assessment marks for each subject is 30. Practical internal assessment marks is based on viva voce and practical records in the semesters and carries 30 marks for each practical paper. The Project internal assessment 30 marks is based on the regular performance of the student during the project work.

Project Report: There shall be a project in the fourth semester for all the specializations. The project report shall be in the form of a dissertation. Out of 100 marks for the project, 30 marks will be for Internal Assessment and the remaining 70 marks will be based on the content of the Project Report and performance of the student in the Viva-voce examination. The evaluation of the project report and viva-voce examination will be done by two examiners (one internal and one external) from the panel of examiners prepared by the BoS and approved by the University.

Question paper pattern for hard core and soft core (4 credits)

PATTERN

The examination marks for hard core (4 credits), soft core (3/4 credits) and open elective (3 credits) theory paper is 70.

Each hard/soft theory paper 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 questions and one question from each part is to be chosen. Part V is compulsory which consists of four questions (one from each part) and two questions are to be answered. Part V carries 10 marks. The model question paper is given below.

M.Sc. Degree Examination

PHYSICS

PHY XXX: Model paper (CBCS) (Hard Core/Soft core (4 credits))

Time: 3 Hours

Max.Marks: 70

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

PART - I

1

(15)

OR

2.

.

(15)

PART - II

3

(15)

OR

4

(15)

PART - III

5

(15)

OR

6

(15)

PART - IV

7

(15)

OR

8

(15)

PART V

9 Answer **any two** of the following: (2x5=10)

a)
b)
c)
d)

Question paper pattern for soft core (3 credits) and open elective

PATTERN

Each soft/open elective theory paper 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 18 marks. Each Part consists of two questions and one question from each part is to be chosen. Part IV is compulsory which consists of six questions (two from each part) and four questions are to be answered. Part IV carries 16 marks. The model question paper is given below.

M.Sc. Degree Examination

PHYSICS

PHYS YYY: Model paper (CBCS)

(Soft core (3 credits/Open elective))

Time: 3 Hours

Max.Marks: 70

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

PART - I

1

(18)

OR

2.

.

(18)

PART - II

3

(18)

OR

4

(18)

PART - III

5

(18)

OR

6

(18)

PART IV

9 Answer **any four** of the following: (4x4=16)

a)
b)
c)
d)
e)
f)

PRACTICAL EXAMINATION: Semester end practical examination for each practical paper 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.

MANGALORE UNIVERSITY

M Sc DEGREE PROGRAMME IN PHYSICS: SEMESTER SCHEME

(Effective from the Academic year 2020- 2021)

C O U R S E P A T T E R N AND S C H E M E OF E X A M I N A T I O N

SEMESTER	Description of the Papers	Teaching Hrs/ week	Credit Hard(H)/Soft(S)/ Open elective(OE)	Max Marks: Exam + IA = Total
I SEMESTER				
PHH 401	Methods of Mathematical Physics - I	4	4 H	70 + 30
PHH 402	Quantum Mechanics I	4	4 H	70 + 30
PHH 403	Classical Mechanics	4	4 H	70 + 30
PHH 404	Electrodynamics	4	4 H	70 + 30
PHP 405	Physics Practicals I (General)	6	3 S	70 + 30
PHP 406	Physics Practicals II (General)	6	3 S	70 + 30
II SEMESTER				
PHH 451	Mathematical Physics II	4	4 H	70 + 30
PHH 452	Quantum Mechanics II	4	4 H	70 + 30
PHH 453	Nuclear and Radiation Physics	4	4 H	70 + 30
PHH 454	Condensed Matter Physics and Electronics	4	4 H	70 + 30
PHE 455	Energy studies	3	3S (OE)	70 + 30
PHP 456	Physics Practicals III (General)	6	3 S	70 + 30
PHP 457	Physics Practicals IV (Electronics)	6	3 S	70 + 30

III SEMESTER				
PHH 501	Atomic and Molecular Physics	4	4 H	70 + 30
PHH 502	Thermodynamics and Statistical Physics	4	4 H	70 + 30
PHS 503	Condensed Matter Physics I	4	4 S	70 + 30
PHS 504	Electronics I	4	4 S	70 + 30
PHS 505	Nuclear Physics I	4	4 S	70 + 30
PHS 506	Condensed Matter Physics II	4	4 S	70 + 30
PHS 507	Electronics II	4	4 S	70 + 30
PHS 508	Nuclear Physics II	4	4 S	70 + 30
PHE 509	Radiation Sources and Hazards	3	3 S (OE)	70+30
PHP 510	Condensed Matter Physics - Practicals I	6	3 S	70 + 30
PHP 511	Electronics - Practicals I	6	3 S	70 + 30
PHP 512	Nuclear Physics – Practicals I	6	3 S	70 + 30
PHP 513	Condensed Matter Physics - Practicals II	6	3 S	70 + 30
PHP 514	Electronics - Practicals II	6	3 S	70 + 30
PHP 515	Nuclear Physics – Practicals II	6	3 S	70 + 30
IV SEMESTER				
PHH 551	Lasers, Vacuum Techniques and Cryogenics	4	4 H	70 + 30
PHH 552	Astrophysics and Relativity	4	4 H	70 + 30
PHS 553	Condensed Matter Physics III	4	4 S	70 + 30
PHS 554	Electronics III	4	4 S	70 + 30
PHS 555	Nuclear Physics III	4	4 S	70 + 30
PHS 556	Condensed Matter Physics IV	4	4 S	70 + 30
PHS 557	Electronics IV	4	4 S	70 + 30
PHS 558	Nuclear Physics IV	4	4 S	70 + 30
PHP 559	Project work	8	4 H	70+30

PHH 401: METHODS OF MATHEMATICAL PHYSICS I **[52 Hrs.]**

Learning Objectives:

- To Provide students the basic Mathematical Methods that will be useful in understanding other courses in the M.Sc. syllabus.
- To revise Vector analysis and introduce Curvilinear coordinate system as a background to understand Quantum Mechanics and Electrodynamics theory.
- To teach advanced methods in Matrices and Complex variables.
- To develop detailed knowledge on Partial differential equation.
- To introduce students into Special functions that is useful in Quantum Mechanics course.
- To make students realize the importance of mathematics in understanding physics.
- To Develop mathematical ability.

Course Outcome (CO)

CO1 The student gains a compressive knowledge on vector analysis and curvilinear coordinates.

CO2 Have knowledge of matrix representation of operators, Hilbert space and diagonalization of matrices.

CO3 Have understanding on complex variables.

C04 Have clear idea of partial differential in equations and boundary value problems in partial differential equations.

CO5 Have knowledge of special function and their applications in physics.

CO6 Students learn required Mathematical techniques that will be useful in many other courses of M.Sc.

CO7 Will have developed analytical, critical reasoning, problem-solving, and communication skills and acquired mathematical habits of mind.

Unit I Vector analysis and curvilinear coordinates: Integration of vector functions - line integrals, surface integrals and volume integrals - vector theorems without proof (Gauss, Green's and Stoke's) 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 orthogonal curvilinear coordinates. Laplacian in orthogonal curvilinear coordinates, spherical polar coordinates, cylindrical coordinates.

Binomial, Poisson and normal distributions. Central limit theorem. [13 hrs]

Unit II Matrices and complex variables: Matrix representation of linear operators, Hermitian and unitary operators, Hilbert space. Diagonalisation of matrices – simultaneous diagonalisation.

Complex variables and integral transforms: Review of functions of a complex variable – Cauchy Riemann conditions. Contour integrals. Cauchy integral theorem, Cauchy integral formula. Taylor and Laurentz series. Zero isolated singular points, simple pole, m^{th} order pole. Evaluation of residues. The Cauchy's residue theorem. The Cauchy principle value. Evaluation of different forms of definite integrals. A digression on Jordan's lemma. [13 hrs]

Unit III Partial differential equations: Review of system of surfaces and characteristics. 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 - solution of 1-, 2- and 3- dimensional wave, heat and Laplace equation and diffusion equation in Cartesian, plane, cylindrical and spherical polar coordinates.
Linear ordinary differential equations of first and second order and applications

[13 hrs]

Unit IV Special functions: Review of power series method for ordinary differential equations – description of beta and gamma functions.

Bessel functions – solution of Bessel's equation - generating function and recurrence relations – orthogonality of Bessel functions.

Legendre polynomials – solution of Legendre equation – generating function and recurrence relations – orthogonality property of Legendre polynomials.

Solution of Hermite equation – Hermite polynomials – generating functions and recurrence relations.

Solution of Laguerre's equation -Laguerre and associated Laguerre polynomials, Generating function, Recurrence relations and Orthogonality. [13 hrs]

Text Books:

1. Arfken G, „Mathematical Methods for Physicists" (Academic Press, 2005)
2. Harper C, „Introduction to Mathematical Physics" (PHI, 1978)
3. Chattopadhyaya P K, „Mathematical Physics" (Wiley Eastern, 1990)
4. Harry Lass, „Vector and Tensor Analysis" (McGraw Hill, 1950)
5. Mary L Boas, „Mathematical Methods in the Physical sciences" (John Wiley, 1983)
6. Joshi A W, „Matrices and Tensors in Physics" (Wiley Eastern, 1995)
7. Ayres F, „Differential Equations" (Schaum series, McGraw Hill, 1992)
8. Spiegel M R, „Vector Analysis" (Schaum series, McGraw Hill, 1997)
9. Ayres F, „Differential Equations" (Schaum series, McGraw Hill)
10. Sneddon I A, „Elementary Partial Differential Equations" (McGraw Hill, 1957)

Reference Books:

1. Bose A K and Joshi M C, „Methods of Mathematical Physics" (Tata McGraw Hill, 1984)
2. Sokolnikoff and Redheffer, „Mathematics of Physics and Modern Engineering, (McGraw Hill, 1958)
3. Irving J and Mullneu N, „Mathematics in Physics and Engineering" (Academic Press, 1959)
4. Kreysig E, „Advanced Engineering Mathematics" (Wiley Eastern, 1969)
5. Mathews J and Walker R L, „Mathematical Methods of Physics" (W A Benjamin, Inc, 1979)

PHH 402: QUANTUM MECHANICS I **[52 hrs.]**

Learning Objectives:

- To teach Physical and Mathematical basis of Quantum mechanics for non-relativistic system.
- To develop basic understanding of the general formulations of quantum mechanics.
- To provide basic knowledge on Fundamental Postulates of Quantum Mechanics
- To study stationery states and Eigen Value Problems.
- To develop proficient in the theory of angular momentum
- To make students able to solve One- and three-dimensional problems in quantum mechanics.

Course Outcome (CO)

CO1 A basic understanding of the general formulations of quantum mechanics.
CO2 Able to apply Matrix formalism of quantum mechanics
CO3 Will have clear understanding of Stationery states and Eigen Value Problems.
CO4 Students have proficient in the theory of angular momentum,
CO5 Will be able to solve one dimensional problem in quantum mechanics.
CO6 Will be able to solve three dimensional problems in quantum mechanics.

Unit I General formulation of quantum mechanics

Schrodinger wave equation - review of concepts of wave particle duality, matter waves, wave packet and uncertainty principle. Schrodinger's equation for free particle in one and three dimensions - equation subject to forces. Probability interpretation of the wave function, probability current density - normalisation of the wave function, box normalisation, expectation values and Ehrenfest's theorem.

[13 hrs]

Unit II Fundamental postulates of QM

Representation of states, dynamical variables - Adjoint of an operator. Eigen value problem - degeneracy. Eigenvalues and eigenfunctions. The Dirac-delta function. Completeness and normalisation of eigen functions. Closure. Physical interpretation of eigen values, eigen functions and expansion coefficients. Momentum eigen functions. [13 hrs]

Unit III Stationary states and eigen value problems

The time independent Schrodinger equation - particle in square well - bound states - normalised states. Potential step and rectangular potential barrier - reflection and transmission coefficients - tunnelling of particles.

Simple harmonic oscillator - Schrodinger equation and energy eigen values - Energy eigen functions. Properties of stationary states. [13 hrs]

Unit IV Angular momentum, parity and scattering

Angular momentum operators, eigen value equation for L^2 and L_z - Separation of variables. Admissibility conditions on solutions - eigen values, eigen functions. Physical interpretation. Concept of parity. Rigid rotator. Particle in a central potential - radial equation.

Three-dimensional square well. The hydrogen atom - solution of the radial equation - energy levels. Stationary state wave functions - bound states. Theory of scattering - the scattering experiment, differential and total cross-section, scattering amplitude, method of partial waves, scattering by a square well potential. [13 hrs]

Text Books:

1. Powell and Crassman, „Quantum Mechanics"(Addison Wesley, 1961)
2. Mathews P M and Venkatesan K, „A Text Book of Quantum Mechanics" (Tata McGraw Hill, 1977)
3. Ghatak A K and Lokanathan S, „Quantum Mechanics", III Edn. (McMillan India, 1985)
4. Sakurai J J, „Modern Quantum Mechanics", Revised Edn. (Addison Wesley, 1994)

Reference Books:

1. Cohen Tannoudji C, Diu B and Laloe, „Quantum Mechanics", Vol. I (John Wiley, 1977)
2. Schiff L I, „Quantum Mechanics", III Edn. (McGraw Hill, 1968)
3. Shankar R, „Principles of Quantum Mechanics" (Plenum, 1980)
4. French A P and Taylor E F, `An introduction to Quantum Physics" (W W Norton, 1978)
5. Gasirowicz, „Quantum Physics" (Wiley, 1974)
6. Wichmann E H, „Quantum Physics" (McGraw Hill, 1971)
7. Quantum Mechanics: Concepts and Applications, Nouredine Zettili (Wiley 2nd edition 2009)

PHH 403: CLASSICAL MECHANICS **[52 hrs]**

Learning Objectives:

- To teach students Advanced Classical mechanics which forms basis for many areas of Physics.
- To make students realize the usefulness of Lagrangian Formulation over Newtonian formulation.
- To introduce students to Hamiltonian formalism.
- To study motion and scattering of particles in central force field.
- To discuss motion in non-inertial frame of reference.
- To teach advanced rigid body dynamics and small oscillations.

Course Outcome (CO)

CO1 Will be able to apply Euler-Lagrange equation to solve problems.
CO2 Will have better understanding of Hamiltonian formalism.
CO3 Will be able to apply knowledge of central forces to solve problems.
CO4 Will have realized advantage of Lagrangian and Hamiltonian formulation over Newtonian formulation.
CO5 Good knowledge of Motion in a Non-inertial reference frames.
CO6 Good knowledge rigid body dynamics and dynamics of small oscillatory systems.
CO7 Will have sufficient background to study other branches of physics such as relativity.

Unit I 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. [13 hrs]

Unit II 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. [13 hrs]

Unit III Central Forces**:** 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, Kepler‟s laws of planetary motion. Newton‟s law of gravitation.

Scattering in Central Force Field: general description of scattering, cross-section, impact parameter, Rutherford scattering, centre of mass and laboratory co-ordinate systems.

Motion in a Non-inertial reference frames: Motion of a particle in a general non-inertial frame of reference, motion of pseudo forces, equation of motion in a rotating frame of reference, the Coriolis force, deviation due east of a falling body, the Foucault pendulum. [13 hrs]

Unit IV Rigid body dynamics: Degrees of freedom of a rigid body, angular momentum and kinetic energies of a rigid body, moment of Inertia tensor, principal moment of inertia, Euler angles, Euler's equations of motion for a rigid body, Torque free motion of a rigid body, precession of earth's axis of rotation.

Small oscillations**:** types of equilibriums, Quadratics forms for kinetic and Potential energies of a system in equilibrium, Lagrange's equations of motion, Normal modes and normal frequencies, examples of (i) longitudinal vibrations of two coupled harmonic oscillators, (ii) Normal modes and normal frequencies of a linear, symmetric, tri-atomic molecule. [13 hrs]

Text Books:

1. Classical Mechanics, H Goldstein , (Addison Wesley, 1980)
2. Classical mechanics, H. Goldstein, C. Poole, J. Safko, (3rd edition, Pearson Educations Inc. 2002).
3. Classical mechanics, K. N. Srinivasa Rao, (University press,2003).
4. Classical mechanics, N. C. Rana and P. S. Joag, (Tata McGraw-Hill,1991).
5. Classical dynamics of particles and systems, J. B. Marion, (Academic press,1970).
6. Introduction to Classical mechanics, R.G.Takwale and P.S.Puranik, (Tata McGraw-Hill 1983).
7. Classical Mechanics, J C Upadhyaya, (Himalaya Publishing House,2005)
8. Classical Mechanics,G. Aruldhas, (Prentice Hall of India,2008)

Reference Books

1 Classical mechanics, L. D. Landau and E. M. Lifshitz, (4th edition, Pergamon press 1985).

2 Lagrangian and Hamiltonian Mechanics, M.G. Calkin, (World Scientific, 1996)

3 Analytical Mechanics, G R Fowles, Holt, Rinehart (1977).

4 Classical Mechanics, Walter Greiner, Springer India (2006).

5 Analytical Mechanics, K A Gamalnath, Narosa, (2011).

6 Classical Mechanics, A K Saxena, CBS Publishers(2010)

PHH 404 : ELECTRODYNAMICS [52 hrs]

Learning Objectives:

- To review and provide detailed basics of Electrostatics.
- To review and provide detailed basics of Magnetostatics.
- To teach the application of Maxwell's equations and Problem-solving techniques.
- To discuss Poynting theorem, Retarded, potentials, Electric and magnetic dipole radiation
- To study the electromagnetic waves and the factors which affect their propagation in different medium and interfaces.
- To provide basic understanding of plasma physics and make students apply the knowledge to study motion of charged particles in various fields

Course Outcome (CO)

CO1 Have the basics of electro and magnetostatics.

CO2 Have the knowledge Maxwell's equations. Will be able to apply Maxwell's equation to solve problems in electrodynamics.

CO3 Have the knowledge of Poynting theorem, Retarded, potentials, Electric and magnetic dipole radiation.

CO4 Have basic understanding of electromagnetic waves and the factors which affect their propagation in different medium and interfaces.

CO5 Will have a basic understanding of plasma physics and apply the knowledge to study motion of charged particles in various fields.

CO6 Will have developed skills required to solve various problems in science which is related to electrodynamics.

Unit I **Electrostatics:**

Gauss's 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. Boundary conditions and uniqueness theorem. Method of images and applications. Multipole expansion. Electric dipole field, Field inside a dielectric-special problems involving linear dielectric. [13 hrs]

Unit II **Magneto statics:**

Biot –Savart law for study current, divergence and curl of magnetic field, Magnetic vector potential, Boundary conditions. Multipole expansion of vector potential. current loops in external fields, Magnetic vector potential due to small current, effect of a magnetic field on atomic orbit, field of a magnetised object, Ampere's law in magnetized materials and applications, Review of magnetisation. Magnetic field inside matter, field of a magnetized object; bound current, physical interpretation of bound current, magnetic field inside the matter. [13 hrs]

Unit III **Electromagnetic waves**:

Review of Maxwell's equations, formulating electrodynamics using scalar and vector potentials, Gauge transformations. Coulomb gauge and Lorentz gauge. Electromagnetic Induction, Poynting theorem, Electromagnetic waves in Vacuum, Energy and momentum of electromagnetic waves. 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. [13 hrs]

Unit IV **Electromagnetic Radiation and Plasma Physics:**

Retarded potentials, Electric and magnetic dipole radiation, Lienard-Wiechert potentials. Fields of a point charge in motion, Power radiated by a point charge, Larmour formula. Magnetism as a relativistic phenomenon.The electromagnetic field tensor notation, potential formulation of electrodynamics

Plasma Physics

Plasma - definition, Debye shielding distance, hydromagnetic equations. Adiabatic invariants, the equation of motion of a plasma fluid, magnetic pressure, plasma confinement, Pinch effect, Plasma as a conducting fluid, Drift velocities, Plasma oscillations, Plasma waves, Propagation of electromagnetic waves in plasma, Magnetic mirrors.

[13 hrs]

Text Books:

1. D.J. Griffiths, „Introduction to Electrodynamics", III Edn. (PHI, 2003)
2. B.B. Laud „Electromagnetics" (New age International PVT. LTD, 1987)
3. P. Lorrain and D. Corson, „Electromagnetic field and waves"(CBS)
4. I.S Grant and W.R. Phillips „Electromagnetism" (John Wiley and sons Ltd.)
5. Pramanik, „Electromagnetism" (PHI,2010)
6. J.D. Jackson, „Classical Electrodynamics" (Wiley eastern,2003)
7. Reitz J R, Milord F J, Christy R W, „Foundations of Electromagnetic Theory", III Edn. (Narosa Publishing House, 1990)
8. Purcell E M, `Electricity and Magnetism", II Edn. (McGraw Hill, 1985)
9. A.R. Choudhari, „The Physics of fluids and plasmas" (Cambridge UP 1998)
10. Chen Francis, „Plasma Physics", II Edn. (Plenum Press, 1984)
11. Bitten Court J A, „Fundamentals of Plasma Physics" (Pergamon Press, 1988)
12. Paul Bellan, „Fundamentals of Plasma Physics" (CUP 2006)

Reference Books:

1 Sommerfeld A, „Mechanics" (Academic Press, 1964)
2 Krauss John D, „Electromagnetics", II Edn. (Tata McGraw Hill, 1973)
3 Singh R N, „Electromagnetic Waves and Fields" (Tata McGraw Hill, 1991).

PHH 405: PHYSICS PRACTICALS I (General)

Learning Objectives:

- To develop experimental skills in students.
- To teach how determine efficiency of a GM counter, Study the beta ray attenuation in matter, Determine of energy gap of a semiconductor, Susceptibility by Quincke's method.
- To demonstrate how determine Modes of vibration of a fixed free bar and hence the elastic properties of materials. Temperature dependence of Hall coefficient, Magnetic susceptibility of hydrated copper sulphate. Study the variation of magnetoresistance of a sample with the applied magnetic field.
- To give them idea about determination of strength of an α-source using SSNTD.
- To identify the transition temperature of a ferroelectric Materials.
- To demonstrate how to determine the dielectric constant of given materials.

Course Outcome (CO)

CO1 The student will know to determine efficiency of a GM counter, Study the beta ray attenuation in matter, Determine of energy gap of a semiconductor, Susceptibility by Quincke's method.

CO2 Will able to determine Modes of vibration of a fixed free bar and hence the elastic properties of materials. Temperature dependence of Hall coefficient, Magnetic susceptibility of hydrated copper sulphate. Study the variation of magnetoresistance of a sample with the applied magnetic field.

CO3 Will able to determine strength of an α-source using SSNTD.

CO4 Able to study the transition temperature of a ferroelectric Materials.

CO5 Able to determine the dielectric constant of given materials.

CO6 Able to analyse data using Origin software

1 Characteristics and efficiency of a GM counter.
2 Study the beta ray attenuation in matter.
3 Determination of energy gap of a semiconductor.
4 Magnetic Susceptibility of Ferromagnetism by Quinke`s method.
5 Modes of vibration of a fixed free bar.
6 Temperature dependence of Hall coefficient.
7 Verification of Arrhenius.
8 Curie temperature.
9 To study the I-V characteristics of solar panel.
10 Photodiode Characteristics.
11 Calibration of thermocouple.
12 To determine the strength of an α-source using SSNTD.
13 Transition temperature of a ferroelectric material
14 Dielectric constant of a given material.
15 Gamma ray Spectrum of Cs-137.
16 Data Analysis

PHP 406: PHYSICS PRACTICALS II (General)

Learning Objectives:

- To develop experimental skills in students.
- To make students setup and study interference and diffraction of light experiment.
- To show students determination of velocity of ultrasonic waves in liquids.
- To demonstrate the determination of the wavelength of light using interferometric experimental techniques.
- To familiarize determination of ionization potential of given source.
- To demonstrate the estimation of the fundaments constant like Planck's constant using simple experiments.
- To make students setup and study the quantum nature of atoms.
- To demonstrate splitting of spectral line in magnetic fields.

Course Outcome (CO)

CO1 The student will be able to setup experiments and study the interference and diffraction of light.

CO2 They will be able to setup experiments to determine velocity of ultrasonic waves in liquids.

CO3. They will be able to determine the wavelength of light using interferometric experimental techniques.

CO4 Will be able to setup experiment to determine the ionization potential of given source.

CO5 Would be able to estimate the fundaments constant like Planck's constant using simple experiments.

CO6 Able to setup experiments to study the quantum nature of atoms.

CO7 Able to setup experiments demonstrate the splitting of spectral line in magnetic fields.

1. Study of interference and diffraction using He-Ne Laser
2. Ultrasonic Interferometer
3. Michelson`s Interferometer
4. Constant deviation Spectrometer
5. Quarter wave plate
6. Diffraction Haloes
7. Fresnel's laws of reflection
8. To determine the ionization potential of given source.
9. To determine the value of Planck's constant using photocell/LED.
10. Babinet Compensator
11. Demonstration of energy quantization using the Frank-Hertz Experiment.
12. Study of Zeeman effect: determination of e/m for an electron
13. Determination of Refractive Index and Thickness of Reflecting Surface Using Laser Beam Interferometry.
14. Wavelength of Laser light Using Diffraction Grating – A Graphical Method
15. Data Analysis

PHH 451 MATHEMATICAL PHYSICS II [52 Hrs.]

Learning Objectives:

- To Provide students the Basic Mathematical methods that will be useful in understanding Other courses in the M.Sc. syllabus.
- To introduce students to detailed Tensor analysis.
- To review and teach advanced Fourier and Laplace Transform.
- To teach Greens function and Integral Equation solving techniques
- To study techniques of Numerical methods that are useful in other courses of Physics.
- To discuss in detail Group theory.
- To develop analytical, critical reasoning, problem- solving, and communication skills and help students acquiring mathematical habits of mind.

Course Outcome (CO)

CO1 Gain knowledge of tensors and able to apply tensors in the analysis various physical phenomenon.
CO2 Have the knowledge of Fourier series and Fourier transformations, and its applications.
CO3 Have the knowledge of Green's functions and applications of Green's functions.
CO4 have Understood techniques of Numerical methods that are useful in other courses of Physics.
CO5 Have the knowledge of group theory and the use of group theory in different branches of physics.
CO6 Will helps all students of physics in developing analytical, critical reasoning, problem-solving, and communication skills and acquiring mathematical habits of mind.

Unit I Tensor analysis: Introduction - rank of a tensor. Transformation of coordinates in linear spaces - transformation law for the components of a second rank tensor. Contra-variant and 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. Line element and Metric Tensor, Christoffel's Symbols of first and second kind, Length of a vector, Angle between vectors, Geodesics, Covariant derivative,
Tensor form of Gradient, Divergence and Curl. [13 hrs]

Unit II Fourier series: Fourier integral and Fourier transform - definition - special form of Fourier integral and properties. Convolution theorem involving Fourier transform. Applications of Fourier transforms. Laplace transform - Convolution theorem involving Laplace transforms. Applications of Laplace transforms.

Green's Functions and Integral Equations: Green's function for one, two and three dimensional equations, Eigen function expansion of Green's functions, Fredholm and Volterra type integral equations, solution with separable kernels, Neumann series method. Non-homogeneous integral equations. [13 hrs]

Unit III Numerical methods:
Data interpretation and analysis. Precision and accuracy. Error analysis, propagation of errors. Linear and nonlinear curve fitting: principles of least squares method- Examples. chi-square test.

Elements of computational techniques: root of functions. Interpolation - Definition of interpolating polynomial - finite difference operators - Newton’s forward and backward interpolation formulas - examples. Extrapolation.

Numerical integration - trapezoid and Simpson’s 1/3rd rule - examples. Solution of ordinary differential equations of first order: Runge - Kutta method of order 4 - examples. Finite difference methods. [13 hrs]

Unit IV Groups - subgroups - classes. Invariant subgroups - factor groups. Homomorphism and Isomorphism. Group representation - reducible and irreducible representation. Schur‟s lemmas, orthogonality theorem. Decomposing reducible representation into irreducible ones. Character of a representation, character table, Construction of representations. Representation of groups and quantum mechanics. Lie groups and Lie algebra. Generators of Unitary Groups, Three dimensional rotation group SO(3), SU(2) and SU(3) groups. The homomorphism between SU(2) and SO(3) groups. [13 hrs]

Text Books:

1. Chattopadhyaya P K, „Mathematical Physics‟ (Wiley Eastern, 1990)
2. Joshi A W, „Introduction to Group Theory‟ (Wiley Eastern, 1995)
3. Spiegel M R, „Vector Analysis‟ (Schaum series, Tata McGraw Hill, 2009)
4. Joshi A W, „Matrices and Tensors in Physics‟ (Wiley Eastern, 199
5. Arfken G, „Methods of Mathematica Physics, (Academic Press 2005)
6. Kreyszig, Advanced Engineering Mathematics, (New Age International, 2004)
7. S.S. Sastry, Introductory Methods of Numerical Analysis, 4th Edition, New Delhi: Prentice Hall of India Pvt Ltd, 2010.
8. Joshi A W, „Introduction to Group Theory‟ (Wiley Eastern, 1995)

Reference Books:

1. Sokolnikoff and Redheffer, „Mathematics of Physics and Modern Engineering, (McGraw Hill, 1958)
2. Irving J and Mullneu N, „Mathematics in Physics and Engineering‟ (Academic Press, 1959)
3. Mary L Boas, „Mathematical Methods in the Physical Sciences‟ (John Wiley, 1983)
4. Mathews J and Walker R L, „Mathematical Methods of Physics‟ (W A Benjamin, Inc, 1979)
5. M.K. Jain, S.R.K. Iyengar and R.K. Jain, Numerical Methods for Scientific and Engineering Computation, 6th Edition, New Delhi: New Age International (P) Limited Publishers, 2012.
6. Sreenivasa Rao K N, „The Rotation and Lorentz Groups and Their Representations for Physicists‟ (John Wiley & sons, 1988)
7. N.Hammermesh,‟Group Theory‟, (Addison-Wesley,1964)
8. M.Tinkham,‟Group Theory and Quantum Mechanics‟, (McGraw-Hill,1964)
9. E.Butkov, ‟Mathematical Physics‟, (Addison-Wesley,1968)
10. P.M.Morse and H.Feshbach,‟Methods of Theoretical Physics‟, (Interscience,1953)

PHH 452: QUANTUM MECHANICS II **[52 hrs.]**

Learning Objectives:

- To teach Physical and Mathematical basis of Quantum mechanics for relativistic system.
- To introduce Matrix formalism of quantum mechanics and hence solve harmonic oscillator problem.
- To discuss in detail angular momentum.
- To introduce approximate methods as an alternative to Schrodinger approach.
- To provide detailed knowledge on Relativistic quantum mechanics and elements of second quantization
- To help students gain an understanding of the basic principles and the theoretical basis of the various fields of physics and the logical relationships of the various fields to quantum mechanics.

Course Outcome (CO)

CO1 Acquire in-depth knowledge about matrix formalism of quantum mechanics.

CO2 Acquire the knowledge of quantum dynamics. Able to apply matrix formalism to solve harmonic oscillator problem.

CO3 The student will be use various approximation methods to solve quantum systems.

CO4 The student would acquire the knowledge of relativistic quantum mechanics and field quantization.

CO5 Gain an understanding of the basic principles and the theoretical basis of the various fields of physics and the logical relationships of the various fields to quantum mechanics.

CO6 Gain sufficient skill to face competitive examinations.

Unit I Matrix formalism of quantum mechanics

Linear vector spaces - orthogonality and linear independence, bases and dimensions, completeness, Hilbert‟s spaces. Hermitian operators. Bra and Ket notations for vectors. Representation theory. Schwartz‟s inequality theorem - proof of Heisenberg uncertainty relation.

[13 hrs]

Unit II Quantum dynamics

Equations of motion - Schrodinger and Heisenberg picture - quantum Poisson bracket. Harmonic oscillator problem solved by matrix method.

Angular momentum - angular momentum operator, commutation relations - raising and lowering operators - eigen values and eigen functions of L^2 and L_z - addition of two angular momentum - Clebech-Gordan coefficients - the 3-j symbol - Pauli spin matrices. [13 hrs]

Unit III Approximation methods

Perturbation theory for discrete levels - equations in various orders of perturbation theory - non-degenerate and degenerate cases, simple examples. Time dependent perturbation theory.

The variation method - the hydrogen molecule - exchange interaction. The WKB method. [13 hrs]

Unit IV Relativistic quantum mechanics and elements of second quantization

Klein-Gordan equation for a free particle - Dirac equation - Dirac matrices. - spin and magnetic moment of the electron.

Transition from particle to field theory. Second quantization of the Schrodinger, Klein, Dirac and Electromagnetic equations (qualitative). Creation and annihilation operators - commutation and anti-commutation relation and their physical implications. [13 hrs]

Text Books:

1. Thankappan V K, „Quantum Mechanics‟ (Wiley Eastern Ltd., 1985)
2. Ghatak A K and Lokanathan S, „Quantum Mechanics‟ (Macmillan, India, 1984)
3. Mathews P M and Venkatesan K, „Text Book of Quantum Mechanics‟ (Tata McGraw Hill, 1976)
4. Powell J L and Crasemann B, „Quantum Mechanics‟ (Addison Wesley, 1961)

Reference Books:

1. Schiff L I, „Quantum Mechanics‟, III Edn. (McGraw Hill, 1969)
2. Merzbecher E, „Quantum Mechanics‟, III Edn. (John Wiley & Sons, 1998)
3. Shankar R, „Principles of Quantum Mechanics‟ (Plenum, 1980)
4. Sakurai J J, „Modern Quantum Mechanics‟ Revised Edn. (Addison-Wesley, 1994)
5. Edmonds, „Angular Momentum in Quantum Mechanics‟ (Princeton University Press, 1960)

PHH 453: NUCLEAR AND RADIATION PHYSICS **[52 hrs]**

Learning Objectives:

- To develop the basic skill of nuclear and radiation physics.
- To study General properties of the nucleus and nuclear decay.
- To understand the interaction of ionizing radiations with matter.
- The teach techniques available to detect ionizing radiation.
- To discuss the application of ionizing radiation.
- To review and provide detailed knowledge on various nuclear models and types of nuclear reactions.
- To familiarize reactor physics.

Course Outcome (CO)

CO1 The students are able to demonstrate a knowledge of fundamental aspects of the structure and properties of the nucleus and radioactive decay.

CO2 Student will be able to explain the interaction of radiation with matter and explain different types of radiation detectors.

CO3 Understanding on different sources of ionizing radiation in the environment.

CO4 Explain different kinds of nuclear reactions and the approaches made to obtain the cross sections.

CO5 Understanding on the application of ionizing radiations in different fields.

CO6 Student will have good grasp on nuclear reactions and reactor physics.

CO7 Able to discuss nuclear and radiation physics connection with other physics disciplines, geology, archelogy and medical diagnostics and therapy.

Unit I General properties of the nucleus and nuclear decay

Constituents of nucleus and their properties. Mass of the nucleus-binding energy. Charge and charge distribution. Estimation of nuclear radii by different methods. Spin statistics and parity. Magnetic moment of the nucleus. Quadrupole moment.

Nuclear decay - Alpha decay - quantum mechanical tunneling - wave mechanical theory. 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). [13 hrs]

Unit II Interaction of radiations and radiation detectors: Interactions of electrons with matter - Specific energy loss, Coulombic mode of interactions, radiative mode of energy loss, electron range and transmission curves.

Interaction of gamma rays with matter - Elastic scattering, photoelectric effect, Compton scattering, Klein-Nishina formula (qualitative) and pair production processes, cross section, gamma ray attenuation, linear and mass absorption coefficients.

Radiation detectors - Gas filled counters - general features - ionization chamber, proportional counter and GM counter.

Radiation quantities and units - radiation exposure, absorbed dose, equivalent dose and effective dose, dose limits. [13 hrs]

Unit III Ionising radiations and applications: Sources of ionising radiations in the environment – terrestrial radiation sources and radionuclides, radioactive series, cosmic radiations and cosmogenic radionuclides. Technologically enhanced radiation sources. Artificial radiation sources artificial radionuclides. Production of radioisotopes using reactors. Application of radioisotopes in medicine, agriculture and industry. Radiation shielding (qualitative treatment).

Nuclear Models: Liquid drop model - semi empirical mass formula, stability of the nuclei against beta decay, mass parabola. Shell model (qualitative) **[**13 hrs]

Unit IV 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. Non-relativistic kinematics. 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. Effect of reflectors. Brief introduction of nuclear fuel cycle. Breeder Reactors. [13 hrs]

Text Books:

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 & II (S Chand & Company, 1994)

Reference Books

1. Patel S B, „Nuclear Physics - An Introduction‟ (Wiley Eastern, 1991)
2. Krane K S, „Introductory Nuclear Physics‟ (John Wiley, 1988)
3. Roy R K and Nigam P P, „Nuclear Physics - Theory and Experiment‟ (Wiley Eastern Ltd., 1993)
4. Singru R M, „Experimental Nuclear Physics‟ (Wiley Eastern, 1972)
5. Zweifel P F, „Reactor Physics‟, International Student Edn. (McGraw Hill, 1973)
6. Kapoor S S and Ramamurthy V S, „Radiation Detectors‟ (Wiley Eastern, 1986)
7. Henry Semat & John R AlBright, „Introduction to Atomic and Nuclear Physics‟ V Edn. (Chapman & Hall, 1972)
8. Burcham W E, „Nuclear Physics‟, II Edn. (Longman, 1963)
9. Mann W B, Ayres R L and Garfinkel, „Radioactivity and its Measurements‟(Pergamon Oxford, 1980)
10. Little field T A and Thorley N „Atomic and Nuclear Physics‟, II Edn. (Nostrand Co., 1988)

PHH 454: CONDENSED MATTER PHYSICS and ELECTRONICS [52 hrs]

Learning Objectives:

- To develop the basic skills of condensed matter physics and electronics.
- To review and teach in detail Elementary Crystallography and X-ray diffraction.
- To review and discuss Free Electron Theory and Band Theory of Solids.
- To teach Phasors and Semiconductor devices.
- To familiarize Operational amplifier and their application.
- To review and discuss Digital electronics.
- To make students solve problems in condensed matter physics and electronics

Course Outcome (CO)

CO1 Student will have the knowledge of elements of crystallography and use of X-ray diffraction method in crystallography.

CO2 Student will gain the basic idea of band theory of solids and the need of band theory to understand the properties of solids.

CO3 Students will gain the knowledge of phasors in the analysis of AC circuits.

CO4 Have an understanding on the use of Laplace and Fourier transforms in circuit analysis.

CO5 Acquire basic knowledge on bipolar and Field effect transistors, operational amplifier and digital electronics.

CO6 Acquired Problem solving skills in condensed matter physics and electronics

Unit I Elementary Crystallography and X-ray diffraction:

Elementary Crystallography**:** 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, zinc blende 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. Systematic absences. Reciprocal lattice - its properties, Ewald's sphere - its construction. Laue and powder experimental methods.

Lattice Vibration**:** Properties of lattice waves, chain of identical atoms and a diatomic linear chain, quantisation of lattice vibrations, phonon, phonon momentum, elastic scattering by phonon, phonon-phonon interaction, anharmonicity and thermal expansion, problems. [13 Hrs]

Unit II Free Electron Theory and Band Theory of Solids: 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, impurity states-donor states, acdeptor states, thermal ionisation of donors and acceptors, temperature effects of mobility, Electrical conductivity of semiconductor. [13 Hrs]

Unit III Phasors and devices

Phasors - Phasor relations for R, L and C - Sinusoidal steady state response of a series

RLC circuit. Fourier series - trigonometric form of Fourier series - complex form of Fourier series. Application of Fourier and Laplace transforms in circuit analysis. 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. SCR characteristics and its use in ac power control

[13 hrs]

Unit IV Operational amplifiers and Digital electronics

BJT differential amplifier. Operational amplifier - voltage/current feedback concepts (series & parallel). Inverting and noninverting configurations. Basic applications of opamps - comparator and Schmitt trigger. IC555 timer - monostable and astable multivibrators. Crystal oscillator using opamp. Voltage regulators – three terminal and SIMPS Tristate devices. Decoders and encoders. Multiplexers and demultiplexers with applications. Digital to analog conversion with R/2R network. Analog to digital conversion using flash technique.

[13 hrs]

Text Books:

1. Hayt W H, Kemmerly J E & Durbin S M, „Engineering Circuit Analysis‟, VI Edn. (McGraw-Hill, 2002).
2. Boylestad R L, „Introductory Circuit Analysis‟, VIII Edn. (Prentice Hall, 1997)
3. Boylestad R L & Nashelsky L, „Electronic Devices & Circuit Theory‟, VIII Edn. (Prentice Hall, 2002).
4. Floyd T L, „Electronic Devices‟, V Edn. (Pearson Education Asia, 2001).
5. Gayakwad R A, „Opamps and Linear Integrated Circuits‟, III Edn. (PHI, 1993).
6. Floyd T L, „Digital Fundamentals‟, VII Edn. (Pearson Education Asia, 2002).
7. Cullity B D and Stock S R, „Elements of X-ray diffraction‟, III Edn. (PH, 2001)
8. Ashcroft F W & Mermin N D, „Solid State Physics‟ (Harcourt, 1976)
9. Verma A R and Srivastava O N, „Crystallography Applied to Solid State Physics‟, II Edn. (New Age, 1991)
10. Kittel C, „Introduction to Solid State Physics‟, IV Edn. (Wiley Eastern, 1974)
11. Cullity B D and Stock S R, „Elements of X-ray diffraction‟, III Edn. (Prentice-Hall, 2001)
12. Ashcroft F W & Mermin N D, „Solid State Physics‟ (Harcourt, 1976)
13. Verma A R and Srivastava O N, „Crystallography Applied to Solid State Physics‟, II Edn. (New Age, 1991)
14. McKelvey J P „Solid State and Semiconductor Physics‟ (Robert E. Kreiger, 1982)
15. Kittel C, „Introduction to Solid State Physics‟, IV Edn. (Wiley Eastern, 1974)
16. Omar M A, „Elementary Solid State Physics‟ (Addison Wesley, 1975)
17. Dekker A J, „Solid State Physics‟ (Macmillan, 1971).
18. Singh J, „Semiconductor Devices‟ (John Wiley, 2001)
19. M A Wahab “ Solid State Physics” Narosa Publication, second edition 2005

Reference Books:

1. Alexander C K and Sadiku M N O, „Fundamentals of Electric Circuits‟ (McGraw Hill International Edition, 2000)
2. Donald Neamen, „Electronic Circuit Analysis and Design‟ II Edn. (Tata McGraw Hill, 2002)
3. Sedra A & Smith K C, „Microelectronics‟, IV Edn. (Oxford University Press, India, 1998)
4. Horenstein M N, „Microelectronic Circuits and Devices‟, II Edn. (PHI, 1996).

PHE 455: ENERGY STUDIES (Open elective) [39 Hrs.]

Learning Objectives:

- To familiarize with renewable energy resources.
- To Study conversation of Solar energy in deferent form in detail.
- To discuss Basics of the Wind energy in detail.
- To introduce Biomass energy and biogas technology.

Course Outcome (CO)

CO1 Upon successful completion, students will have the knowledge of renewable energy resources.

CO2 Will have a good understanding on conversation of Solar energy in deferent form

CO3 Will have a good understanding of Basics of the Wind energy

CO4 Scientific knowledge about biomass energy and biogas technology.

Unit I Renewable energy resources: Forms of Energy, Conservation of Energy, Nature of solar radiation, Spectral distribution of extra-terrestrial radiation, Estimation of extra-terrestrial solar radiation, Radiation on horizontal and tilted surfaces.

Conversion of Solar Energy in different forms: Various ways to convert solar energy into different forms. Solar active and passive systems, Types of solar passive systems, design aspects of solar passive systems.

Basic principle of solar photovoltaic (SPV) conversion, Block diagram of general SPV conversion system and their characteristics, different configurations, Applications (such as street light, water pumps, Radio/TV, Small capacity power generation). [13 hrs]

Unit II Basics of the Wind energy: Wind Energy Origin and classification of winds, basic principle of wind energy conversion, Extraction of maximum power from wind and its dependence on various parameters. Wind Mills, types of wind mills, Vertical axis and Horizontal axis wind mills-their performance, Merits and Demerits, Limitations of wind energy conversions. [13hrs]

Unit III Biomass energy and biogas technology: Nature of Biomass as a fuel, Properties of biomass, Biomass energy conversion processes, agriculture crop and forestry residues used as fuels, Physical, chemical and biological conversion of biomass into useful form of energy; Gasification, types of gasification Importance of biogas technology, Aerobic and anaerobic bioconversion process, Factors affecting Bio-digestion, Types of biogas plants, Applications of biogas.

Biofuels: Types of biofuels, Production processes, Biofuel applications, Ethanol as a biofuel. [13 hrs]

References

1. PeterAAdvances in energy systems and technology‟, (Academic Press, USA, 1986).
2. NevilleC.R.,„„Solarenergyconversion:Thesolarcell‟‟,(ElsevierNorth-Holland, 1978).
3. DixonA.E.andLeslieJ.D.,„„Solarenergyconversion‟‟,(PergamonPress,NewYork, 1979).
4. RavindranathN.H.,„„Biomass,energyandenvironment‟‟,(OxfordUniversityPress, 1995).

5. Cushion E., Whiteman A. and Dieterle G., (World Bank Report,2009).
6. TEDDY Year Book, (Tata Energy Research Institute (TERI) Publication, New Delhi, 2018).
7. World Energy Resources, Charles E. Brown, (Springer Publication), 2002.
8. Handbooks of Solar Radiation, A. Mani, (Allied Publishers), 1980.
9. Solar Energy Fundamentals and Applications, H. P. Garg and Satya Prakash, (Tata McGraw Hill), 1997.
10. Treatise on Solar Energy, H. P. Garg, Volume 1, 2 and 3, (John Wiley and Sons), 1982.
11. Principles of Solar Engineering, F. Kreith and J. F. Kreider, (McGraw Hill), 1978.
12. Principles of Solar Energy Conversion, A. W. Culp (McGraw Hill International Publication, 1991).
13. Solar Energy-Principles of Thermal Collection and Storage, S. P. Sukhatme, 2nd Edition. (Tata McGraw Hill Publication Co. Ltd.,), 1976.
14. Solar Energy Utilization, G. D. Rai, (Khanna Publishers), 1996.
15. Solar Thermal Engineering, J. A. Duffie, (Academic Press, 2013).
16. Renewable Energy Sources and Conversion Technology, N. K. Bansal, M. Kleeman and S. N. Srinivas, (Tata Energy Research Institute, New Delhi), 1996.

PHH 456 : PHYSICS PRACTICALS III (General)

Learning Objectives:

- To develop the skills required for experimental study of physics.
- To teach how to determine: Half-life of material like K-40, Thermoelectric constant of materials. Gamma ray Spectrum of Cs-137.
- To discuss the determination of Ferroelectric Curie temperature, study the of effect of white light (sun tracking) on energy generation by solar PV module and I-V characteristic of solar cell, measure the variation of dielectric constant with temperature.
- To study the: transition temperature of ferrites, Hall effect and temperature dependence of Hall coefficient.
- To familiarise measurement of variation of dielectric constant with temperature.
- To teach data analysis using Origin Software.

Course Outcome (CO)

CO1 The student will know to determine: Half-life of material like K-40, Thermoelectric constant of materials. Gamma ray Spectrum of Cs-137.

CO2 Will able to determine Ferroelectric Curie temperature, study the of effect of white light (sun tracking) on energy generation by solar PV module and I-V characteristic of solar cell, measure the variation of dielectric constant with temperature.

CO3 Will able to study the: transition temperature of ferrites, Hall effect and temperature dependence of Hall coefficient.

CO4 Will able to measure the variation of dielectric constant with temperature.

CO5 Will be able to analyse experimental data using Origin Software.

CO6 Will get innovative ideas to do new experiments.

1. Half-life of K-40
2. Thermoelectric constants
3. Creep Constants
4. Estimation of effect of white light (sun tracking) on energy generation by solar PV module.
5. Capacitance-Voltage Characteristics of given Material.
6. Four Probe Method.
7. Verification of Inverse square law (G.M.tube)
8. Transition temperature of ferrites.
9. Hysteresis Loop of Magnetic Material.
10. To study the variation of magnetoresistance of a sample with the applied magnetic field.
11. Lattice Dispersion.
12. UV-Visible Spectroscopy
13. Determination of Unknown Energy of Gamma Source using GRS.
14. Data Analysis

PHP 457: PHYSICS GENERAL PRACTICALS IV (Electronics)

Learning Objectives:

- To develop the skills required for experimental study of physics.
- To familiarize construction of clipping and clamping circuits, differentiator & integrator circuits, logic gates.
- To study the UJT characteristics and relaxation oscillator.
- To expose students to wide applications of Op-amps in electronics.
- To teach students the construction of MOSFET common source amplifier.
- To make students know construction of BJT differential amplifier, Voltage regulator (with series pass transistor) / 3 pin regulator, Wein bridge oscillator.

Course Outcome (CO)

CO1 The student will know to construct clipping and clamping circuits, differentiator & integrator circuits, logic gates.

CO2 Will be able to study the UJT characteristics and relaxation oscillator.

CO3 The student will be exposed to wide applications of Op-amps in electronics.

CO4 Able to construct MOSFET common source amplifier.

CO5 The student will know to construct BJT differential amplifier.

CO6 The student will know to construct and study Voltage regulator (with series pass transistor) / 3 pin regulator, Wein bridge oscillator.

1. Clipping and clamping circuits
2. Differentiator & integrator circuits
3. Logic gates.
4. UJT characteristics - relaxation oscillator.
5. Op-amp circuits - voltage to current converter, current to voltage converter, active limiter and active clamper.
6. Active filters – high pass, low pass, band pass and band stop
7. MOSFET common source amplifier.
8. BJT differential amplifier.
9. Voltage regulator (with series pass transistor) / 3 pin regulator.
10. Wein bridge oscillator.
11. Voltage Control Oscillator.
12. Astable and Monostable multivibrators using IC555.
13. Multiplexers and Demultiplexers.
14. Encoders and Decoders
15. Data Analysis

PHH 501: ATOMIC AND MOLECULAR PHYSICS **[52 Hrs.]**

Learning Objectives:

- To develop sufficient background for the theoretical and experimental study of atomic and molecular spectroscopy.
- To make student learn to use spectroscopy as a tool for studying the structures of atoms and molecules.
- To teach spectra of single and multi-electron atoms.
- To discuss X-ray Spectra and Resonance spectroscopy.
- To introduce Microwave spectra, infra-red spectra and Raman spectroscopy.
- To familiarize with electronic spectroscopy.
- To develop skill to solve problems based on atomic and molecular physics.

Course Outcome (CO)

CO1 On completion of this course, students should be able to use spectroscopy as a tool for studying the structures of atoms and molecules.

CO2 Student be able to identify analytical methods for finding the constituents in material having unknown chemical composition.

CO3 The knowledge can be used in astronomy to study spectral emission lines of distant galaxies in order to understand rapidly expanding universe.

CO4 The course definitely makes the candidate to have the skill to get employed in various laboratories, for carrying out research and developmental activities using spectroscopic techniques.

CO5 Students will be able to solve applied problems based on atomic and molecular physics.

CO6 Students will get ideas to take up research in spectroscopy.

Unit I Spectra of single and multi-electron atoms: Review of atomic models. Simple spectra of hydrogen and hydrogen like ions - energy levels, quantum numbers, electron spin, Stern - Gerlac experiment, fine structure, total angular momentum, Spin-orbit coupling, hydrogen energy levels, relativistic correction, radiation corrections, transition rates, selection rules.

Exclusion principle, ground state of multi electron atoms, periodic table. 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. Simple spectra of trivalent atom (qualitative). Quantum mechanical treatment of fine and hyperfine structure. Zeeman effect (classical & quantum mechanical treatment) Paschen-Back effect, Stark effect. [13 hrs]

Unit II X-ray Spectra and Resonance spectroscopy: Review of emission & 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 [both hydrogen nuclei and other than hydrogen] techniques & instrumentation, structural study, electron spin resonance spectroscopy. [13 hrs]

Unit III Microwave spectra, infra-red spectra and Raman spectroscopy: Theory of rotational spectra of diatomic molecules, selection rule, Experimental technique, Microwave spectrometer, structural information. Microwave oven.

Theory of vibrating rotator, vibration - rotation spectra, IR spectrometer. Application in structural analysis.

Quantum theory of Raman effect. Rotational and vibrational Raman spectra. Raman spectrometer. Laser Raman studies. F T Raman spectroscopy. F T Raman spectrometer. [13 hrs]

Unit IV Electronic spectroscopy: 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. [13 hrs]

Text Books:

1 Ghoshal S N, „Atomic and Nuclear Physics", Vol. I & II (S Chand & 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", IV Edn. (Tata McGraw Hill, 1994)

Reference books:

1. Kuhn H G, „Atomic Spectra", III Edn. (Benjamin, 1977)
2. Haken H & Wolf H C, „Atomic and Quantum Physics", V Edn. (Springer-Verlag, 1997)
3. Henry Semat & John R AlBright, „Introduction to Atomic and Nuclear Physics" V Edn. (Chapman & Hall, 1972)
4. Chatwall Gurdeep, „Spectroscopy", III Edn. (Himalayas, 1994)
5. Robert Eisberg & R Resnick, „Quantum Physics of Atoms, Molecules, Solids, Nuclei & Particles", II Edn. (John Wiley & Sons, 1985)
6. Straughan B P and Walker S, „Spectroscopy", Vol. I, II and III (Chapmann & Hall, 1976)
7. Svanberg S, „Atomic and Molecular Spectroscopy", II Edn. (Springer Verlag, 1992)
8. Herzberg, „Molecular Spectra and Molecular Structure", Vol. I, II & III (Van Nostrand Co., 1966).

PHH 502: THERMODYNAMICS AND STATISTICAL PHYSICS [52 Hrs.]

Learning Objectives:

- To Provide basic theoretical background of thermodynamics and statistical physics.
- To give an idea basics of Thermodynamics, Liouville's theorem, probability - thermal equilibrium.
- To discuss approaches in Classical and Quantum Statistics.
- To familiarize students with Bose-Einstein and Fermi-Dirac distributions and degenerate Fermi and Bose gases - Bose-Einstein condensation.
- To study discuss Brownian motion.
- To familiarize Langevin equation for random motion, Random walk problem. Diffusion and Einstein relation for mobility.

Course Outcome (CO)

CO1 On completion of this course, student will have an idea of basics of Thermodynamics, Liouville's theorem, probability - thermal equilibrium.

CO2 Students will have understood how statistical mechanics serve as a tool to study thermodynamics.

CO3 Students will the difference in approach of classical statistics and Quantum statistics.

CO4 Student will have knowledge of Bose-Einstein and Fermi-Dirac distributions and degenerate Fermi and Bose gases - Bose-Einstein condensation.

CO5 The candidate will have basic understanding of Boltzmann distribution, calculation of velocities - average and r.m.s velocities Gibbs‟ paradox, Sackur - Tetrode equation

CO6 The student will come to know the basics of Brownian motion: Langevin equation for random motion, Random walk problem. Diffusion and Einstein relation for mobility.

Unit I Thermodynamics: Concept of entropy - principle of entropy increase - entropy and disorder. Enthalpy - Helmoltz and Gibb‟s functions. Maxwell‟s relations - TdS equations - energy equations - Heat capacity equations - heat capacity at constant pressure and volume. Phase space and ensembles - Lioullis theorem, probability - thermal equilibrium. [13 hrs]

Unit II Classical statistics: Boltzmann distribution, calculation of velocities - average and r.m.s veleocities Gibbs‟ paradox, Sackur - Tetrode equation, partition functions - translational partition funciotn, vibrational, rotational and electronic partition functions. Boltzmann equipartition theorems. Application to specific heats. [13 hrs]

Unit III Quantum statistics: 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. Principle of detailed balance.

Fluctuations - Fluctuations in canonical, grand canonical and microcanonical ensembles. Number fluctuations in quantum gases. [13 hrs]

Unit IV Brownian motion: Langevin equation for random motion, Random walk problem. Diffusion and Einstein relation for mobility.

Introduction to nonequilibrium processes.

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. [13 hrs]

Text Books:

1. Zeemansky 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)

Reference Books:

1. Kittel C and Kroemer H, „Thermal Physics‟, II Edn. (CBS Publ., 1980)
2. Chandler D, „Introduction to Modern Statistical Mechanics‟ (Oxford university Press, 1987)
3. Reichl L E, „A Modern Course in Statistical Physics‟ (University of Texas Press, 1980)
4. Landau and Lifshitz, „Statistical Physics‟, III Edn. (Oxford, Pergamon, 1980)
5. Gupta M C, „Statistical Thermodynamics‟ (New Age, 1995)
6. Reif F, „Fundamentals of Statistical and Thermal Physics‟ (McGraw Hill, 1965)

PHS 503: CONDENSED MATTER PHYSICS I **[52 Hrs.]**

Learning Objectives:

- To provide basic theoretical background of crystallography.
- To introduce different types of X-ray diffractometers.
- To discuss elastic and thermal properties of crystals.
- To teach Dielectric and Ferroelectric properties of solids in detail.
- To study optical properties of solids in detail.

Course Outcome (CO)

CO1 On completion of this course, student will have good understanding of basics of Crystallography, point groups.
CO2 Students will have basic idea of X-ray diffractometers.
CO2 Student will have knowledge of elastic properties and thermal properties of crystals.
CO3 The candidate will have basic understanding of Dielectric and ferroelectric properties of solids.
CO4 The student will have a broad understanding of Optical properties of Solids.
CO6 will be able to solve applied problems on condensed matter physics.

Unit I Crystallography

Symmetry elements and symmetry operations. Point symmetry elements and point groups, Hermann-Mauguin symbols of point groups, stereographic projection. Getting 32 crystallographic point groups when 7 crystal systems are combined with point symmetry elements. The stereographic projections of point groups. Screw and glide plane symmetries. Space groups. Getting 230 space groups combining the 14 Bravais lattices, the 32-point groups, screw axes and glide planes. Illustration of space groups for triclinic and monoclinic systems.

Modern powder X-ray diffractometer with Bragg-Brentano geometry. Powder diffraction analysis – qualitative analysis, quantitative Analysis. Peak shape and peak width analysis, information's from peak positions and peak intensity. Intensity corrections. Precise lattice parameter determination for cubic crystals. Structure factor calculations. Rietveld Methods of structure refinement. Direct method and Patterson methods of structure solutions, Manual and autoindexing of diffraction patterns. Manual indexing x-ray diffraction patterns of cubic and non-cubic crystals, determination of lattice parameters. Modern single crystal X-ray diffractometers and single crystal X-ray diffraction analysis.

Disordered solid structure - Amorphous solid, quasi crystal and liquid crystals.
[13 hrs]

Unit II Elastic properties and thermal properties

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. [13 hrs]

Unit III Dielectric and Ferroelectric properties of solids

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.

Ferroelectric: 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. [13 hrs]

Unit IV Optical properties of Solids

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; [13 hrs]

Reference Books:

1. Cullity B D and Stock S R „Elements of X ray Diffraction‟, III Edn. (Prentice Hall, 2001)
2. Verma A R and Srivastava O N, „Crystallography Applied to Solid State Physics‟, II Edn. (New Age, 1991)
3. Woolfson M M, „An Introduction to X-ray Crystallography‟ (Cambridge-Vikas, 1970)
4. Buerger M J, „X-ray Crystallography‟ (John Wiley, 1942)
5. Brusch P : „Phonons : Theory & Experiments‟, Vol I, II & III (Springer Verlag, 1987)
6. Kittel C, „Introduction to Solid State Physics‟, IV Edn. (Wiley Eastern, 1974), VII Edn. (John Wiley, 1995)
7. Ashcroft N W and Mermin N D, „Solid State Physics‟ (Harcourt, 1976)
8. Ibach H and Luth H, „Solid State Physics‟, II Edn. (Springer, 1996)
9. Ziman J M, „Principles of the Theory of Solids‟, II Edn. (Vikas Publ., 1979).
10. Applied Solid State Physics by Rajnikant, Wily India, 2011.
11. Solid State Physics: An Introduction to Theory and Experiment by H. Ibach and H. Luth, Springer-Verlag, 2009.
12. Principles of the Theory of Solids (2nd edition) by J. M. Zimam, Cambridge University press, 1972.

PHS 504: ELECTRONICS I **[52 Hrs.]**

Learning Objectives:

- To introduce Printed circuit board design techniques.
- To familiarize IC fabrication technologies.
- To teach Characteristics and simple applications of special semiconductor devices
- To provide applications of OP-Amp.
- To study Precision triangle & square wave generator
- To introduce Digital IC technologies and interfacing different logic families

Course Outcome (CO)

CO1 The student will be well versed with the designing and fabrication of printed circuit board (PCB)

CO2 student will be familiar with fabrication of integrated circuits (IC).

CO3 The student will have good understanding of characteristics and applications of special semiconductor devices.

CO4 Will be able to handle Operational amplifier

CO5 The student will have good understanding of Precision triangle & square wave generator

CO6 Will have knowledge of digital IC technologies and interfacing different logic families

Unit I Printed circuit board design techniques- Definition and evolution of PCB, Types of PCBs, Layout design and artwork preparation, Materials and aids, Component spacing and conductor spacing, Materials and aids. PCB manufacturing – copper clad laminates, Etching, Photoprinting, Screen printing. Multilayer boards. Soldering techniques – wave soldering.

IC fabrication technologies - wafer preparation - chemical vapour deposition - diffusion - ion implantation – photolithography. Fabrication of resistors, capacitors, BJT and MOS [13 hrs]

Unit II Characteristics and simple applications of special semiconductor devices - 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 [13 hrs]

Unit III Operational amplifiers: Voltage references (5V) - voltage level detector - Comparator IC 311 - Phase shifter - precision rectifier - peak detector - instrumentation amplifier – Noise in electronic devices. 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 – IC9400. Analog multiplier - IC AD633 - squaring a dc voltage and doubling the frequency of ac. Frequency multiplier using phase locked loop IC565. [13 hrs]

Unit IV Digital IC technologies and interfacing different logic families. Programmable logic devices - Programmable array logic PAL 16L8 - Generic array logic GAL 22V10. PLD programming using ABEL.– Implementation 8 bit serial in/parallel out shift register using GAL 22V10. Digital to analog converter AD558. Analog to digital conversion - Successive approximation ADC - microprocessor compatible ADC AD670.

[13 hrs]

Text Books:

1. Walter C Bosshart, „Printed Circuit Boards - Design and Technology" (Tata McGraw Hill, 1983)
2. Jaspreet Singh, „Semiconductor Devices" (McGraw Hill, 1994)
3. Boylestad R & Nashelsky L, „Electronic Devices and Circuit Theory" VIII Edn. (PHI, 2002)
4. Coughlin R F & Driscoll F F, „Operational Amplifiers and Linear Integrated Circuits", VI Edn. (Pearson Education Asia, 2002).
5. Gayakwad R A, „Opamps and Linear Integrated Circuits" IV Edn. (PHI, 2002)
6. Floyd T L, „Digital Fundamentals", VII Edn. (Pearson Education Asia, 2002)

Reference Books:

1. Neamen Donald, „Electronic Circuit Analysis and Design" II Edn. (Tata McGraw Hill, 2002)
2. Floyd T L, „Electronic Devices", V Edn. (Pearson Education Asia, 2001)
3. Sedra A & Smith, „Microelectronics" IV Edn. (Oxford University Press, India, 1998)
4. Franco S, „Designing with Operational Amplifiers and Analog Integrated Circuits", III Edn. (McGraw Hill, 2001)
5. Tocci R J, „Digital Systems, Principles and Applications", VIII Edn. (Pearson Education Asia, 2001)
6. Wakerly, „Digital design", III Edn. (Expanded), (Pearson Education Asia, 2002)
7. Winzer J, „Linear integrated circuits" (Saunders College Publ., 1992).

PHS 505: NUCLEAR PHYSICS I **[52 Hrs.]**

Learning Objectives:

- To teach Interaction of particulate radiations and radiation dosimetry
- To review and discuss basic and advanced Nuclear detectors.
- To introduce Nuclear electronics involved in nuclear devices.
- To familiarize particle accelerators and application.
- To provide sufficient background knowledge to pursue research in nuclear reactions.

Course Outcome (CO)

CO1 Able to explain Interaction of particulate radiations and radiation dosimetry
CO2 Able to discuss different type of Nuclear detectors.
CO3 Able to learn fabrication techniques of different nuclear detectors.
CO4 Explain Nuclear electronics involved in nuclear devices.
CO5 Explain different kinds of particle accelerators and application.
CO6 Attain sufficient knowledge to pursue research in nuclear reactions.
CO7 Attain sufficient knowledge to pursue research in nuclear reactions.

Unit I Interaction of particulate radiations and radiation dosimetry: Interaction of heavy charged particles with matter - stopping power, Bethe-Bloch formula, energy loss characteristics, Bragg curves, practical range of charged particles, scaling laws.

Interaction of neutrons - Elastic scattering, inelastic scattering, capture reactions, cross sections, neutron attenuation.

Radiation dosimeters – Thermoluminescent dosimeters, Solid State Nuclear Track Detectors, Bubble detectors. [13 hrs]

Unit II Nuclear detectors: Scintillation detectors – organic and inorganic scintillators, basic scintillation process, photomultiplier tube, NaI(Tl) gamma ray scintillation spectrometer, calibration of the spectrometer, spectrum details.

Semiconductor detectors - physics of semiconductor detectors, diffused junction, surface barrier, ion-implanted, Si(Li) and Ge(Li) detectors. HPGe gamma ray spectrometer, calibration of the spectrometer, spectrum details.

[13 hrs]

Unit III Nuclear electronics

Preamplifier circuits, charge sensitive pre-amplifiers, pulse shaping, pulse stretching. Linear amplifiers, linear pulse amplifier. Pulse discriminators, single channel analysers, coincidence and anticoincidence circuits. Flash ADCs, Wilkinson type ADCs, multichannel analysers. Basic principles of measurement techniques- collimation, geometry, shielding.

[13 hrs]

Unit IV Particle accelerators and Applications

Classification and principles of operation of DC, Linear and Cyclic accelerators, Synchrotron Radiation Sources, Storage rings. Accelerator Driven Sub-critical Systems, Measurements of percentage depth dose and profiles of photons and electron beams from accelerators - Relative dosimetry. Particle energy, flux, fluence, range, exposure and absorption. Accelerator shielding - Safety aspects of accelerators, Accelerators in medical and industrial applications.

[13 hrs]

Text Books:

1. Emilio Segre, „Nuclei and Particles‟, II Edn. (Benjamin, 1977)
2. Ghoshal S N, „Atomic and Nuclear Physics‟, Vol. II (S Chand & Company, New Delhi, 1994)
3. Kenneth S Krane, „Introductory Nuclear Physics‟ (John Wiley, 1986)
4. Knoll G F, „Radiation Detection and Measurement‟, II Edn. (John Wiley, 1989)
5. Evans R D, „Atomic Nucleus‟ (Tata McGraw Hill, 1972)
6. Delaney, „Electronics for Physicists, Prentice Hall, Europe, 1080.
7. Wallemar Scharf `Particle Accelerators and their uses‟ (Harwood Acasemic Publishers, 1986)

Reference Books:

1. Enge H, „Introduction to Nuclear Physics‟ (Addison Wesley, 1988)
2. Paul E B, „Nuclear and Particle Physics‟ (North Holland, 1969)
3. Singru R M, „Experimental Nuclear Physics‟ (Wiley Eastern, 1972)
4. Kapoor S S and Ramamoorthy V S, „Radiation Detectors‟ (Wiley Eastern, 1986)
5. Burcham W E, „Nuclear Physics‟, II Edn. (Longman, 1963)
6. Marmier D and Sheldon E, „Nuclear Physics‟, Vol. I, II (Academic Press, 1969)

PHS 506 : CONDENSED MATTER PHYSICS II [52 Hrs.]

Learning Objectives:

- To review and teach band theory of solids in detail.
- To discuss Semiclassical Theory of Transport of Solids
- To study fermi energy and its effect on various parameters of semiconductors.
- To provide good knowledge of Basics of semiconductor alloys and heterostructures.
- To develop problem solving skills in condensed matter physics.

Course Outcome (CO)

CO1 The student will have understanding of Band theory of solids
CO2 Good understanding of Transport properties
CO3 Will be exposed to Semiconductors
CO4 Will have a good knowledge of Basics of semiconductor alloys and heterostructures.
CO5 Will be able to solve problems based on topics discussed in the course.
CO6 Students will get motivated to take up research in condensed matter physics.

Unit I Band theory of solids

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

A brief discussion on the following energy band theories: The orthogonalized plane wave (OPW) method, the pseudopotential method, the cellular method, The augmented plane wave (APW) method, the Green's function method (KKR).

Brief mention of the experimental methods in Fermi surface studies. Quantization of orbits in a magnetic field. Description of Fermi surface determination using de Haas – van Alphen effect. [13 hrs]

Unit II Semiclassical Theory of Transport of Solids

Setting up of Boltzmann transport equation. Linearization of Boltzmann transport equation. Derivation of electrical conductivity using Boltzmann transport equation. Calculation of relaxation time. Impurity scattering. Ideal resistance. Carrier mobility. Transport equation under temperature gradient as well as applied electric field in the specimen. Thermal conductivity. Thermoelectric effects. Lattice conduction. Phonon drag. The Hall effect. The two-band-model: magnetoresistance. Electromagnetic wave equation in solids. Complex refractive index. Reflection coefficient. Boltzmann equation for a distribution that may vary in space and time- AC conductivity. Complex refractive index with frequency dependent conductivity and optical properties of the materials. Anomalous shin effect. The magnetic field effects on an electron state in a metal. Cyclotron resonance in metals. [13 hrs]

Unit III Semiconductors I

Extrinsic semiconductors. An estimate of donor and acceptor ionization energies in semiconductors using hydrogenic model, and the experimental values of typical donor and acceptor ionization energies in Si, Ge, and GaAs. Fermi energy variation with dopant density at moderate and very low temperatures. The temperature dependence of carrier concentration, mobility, and electrical conductivity. Qualitative description on the constant energy surfaces for electrons for the typical semiconductors such as Si, Ge and GaAs. Cyclotron resonance in semiconductors with spherical energy surfaces. The experimental results of cyclotron resonance in Si and Ge, The derivation of the expression for the cyclotron resonance frequency in Si and Ge, and the explanation of the experimental observations.

Excess carriers. Quasi-Fermi level. Generation and recombination of carriers. Continuity equation for excess carriers. P-N junctions: Properties of abrupt and graded p-n junctions. Rectification process. Derivation of ideal current voltage characteristics. Capacitance of p-n junction diode.

Metal semiconductor Schottky and Ohmic contacts:
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 diode. Ohmic contacts. . [13 hrs]

Unit IV Semiconductors II:
Low-dimensional Semiconductor structures: Basic concepts of semiconductor alloys and heterostructures. 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.

Optoelectronic devices: Light emitting diodes- homo and heterojunctions. Semiconductor Lasers- Heterojunction and quantum well lasers.

Photodetectors and solar cells: P-N and P-I-N Photodiodes. Heterojunction Photodiodes. Metal-Semiconductor Photodiodes. Avalanche photodiodes (APDs). Phototransistors. Quantum well InfraRed Photodetectors (QWIPs). Solar cells.

Amorphous semiconductors (Qualitative aspects only): Introduction: Band structures and density of states. Structure of amorphous semiconductors and structural models. Electrical and Optical properties.

Organic Semiconductors (Qualitative aspects only): Introduction, doping, electrical and optical properties. Organic semiconductor Devices.
[13 hrs]

Reference Books:

1. Kittel C, „Introduction to Solid State Physics", IV Edn. (Wiley Eastern, 1974), VII Ed (John Wiley, 1995)
2. Ibach H and Luth H, „Solid State Physics" II Edn. (Springer, 1996)
3. Ziman J M, „Principles of the Theory of Solids" II Edn. (Vikas Publ., 1979)
4. Mckelvey J P, „Solid State and Semiconductor Physics" (Robert E Kreiger, 1982)
5. Sze S M, „Semiconductor Devices Physics and Technology" (John Wiley, 1985, 2003)
6. S. M, Sze and K. K. Ng, „Physics of Semiconductor Devices" (3rd Edition, Wiley

2006).
7. B. G. Streetman and S. Banerjee, „Solid State Electronic Devices‟ 4rd to 6th Edition (PHI), 2006.
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, (Advances in condensed matter science, Vol.5, D. D. Sharma, G. Kotliar andY. Tokura. Taylor& Fransis, 2003).
12. S. R. Elliot, „Physics of Amorphous Materials, 2nd Ed. (Longman Scientific & Technical, London), 1985.

PHS 507 : ELECTRONICS II **[52 Hrs.]**

Learning Objectives:

- To provide good understanding of Transmission lines
- To give basic idea of Wave guides and antenna
- To introduce analog modulation and demodulation
- To familiarize with satellite communication
- To provide basic idea on microwave devises.

Course Outcome (CO)

CO1 Good understanding of Transmission lines
CO2 Good understanding of Wave guides and antenna
CO3 Will be exposed to Analog modulation and demodulation
CO4 Will have good exposure on microwave devices and satellite communication
CO5 Will have good exposure in satellite communication.
CO6 Will have good understanding of Antennas.

Unit I Transmission lines

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. [13 hrs]

Unit II Wave guides and antenna

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. [13 hrs]

Unit III Analog modulation and demodulation

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 [13 hrs]

Unit IV Microwave devices and Satellite communication (qualitative)

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 [13 hrs]

Reference Books:

1. Ryder J D, „Networks, Lines and Fields" II Edn. (PHI, 1997)
2. Tomasi Wayne, „Electronic Communication Systems", (Pearson Education Asia, 2001)
3. Kennedy and Davis, „Electronic Communication Systems", IV Edn. (Tata McGraw Hill, 1993)
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).

PHS 508 : NUCLEAR PHYSICS II **[52 Hrs.]**

Learning Objectives:

- To introduce Nuclear spectroscopy
- To provide basic idea of heavy ion physics
- To Review of deuteron problem and hence discuss nuclear forces
- To study scattering in detail.
- To provide sufficient background knowledge to pursue their career in research.

Course Outcome (CO)

CO1 On completion of the course, the candidates will be able to explain nuclear spectroscopy.
CO2 Able to explain heavy ion physics
CO3 Would have understood deuteron problem and nuclear forces
CO4 Able to explain Scattering in detail.
CO5 would get sufficient background knowledge to pursue their career in research in nuclear physics
CO6 Students will get ideas of different techniques in nuclear spectroscopy.

Unit I Nuclear spectroscopy

Beta ray spectroscopy. The shape of beta spectra. The rest mass of neutrino - neutrino recoil experiment. Inverse beta decay. Double beta decay.
Gamma ray spectroscopy - life time measurements. gamma-gamma, beta-gamma correlation studies - decay schemes - angular distribution of gamma rays from oriented nuclei, polarization of gamma rays [13 hrs]

Unit II Heavy ion physics

Special features of heavy ion Physics - remote heavy ion electromagnetic interaction - Coulomb excitation - close encounters - grazing interactions - particle transfer - direct and head on collision - compound nucleus and quasi molecule formations. [13 hrs]

Unit III Review of deuteron problem and nuclear forces

Deuteron as mixture of S and D states - admixture in the deuteron wave function - magnetic and electric quadrupole moment of deuteron from S and D mixture. Ground state wave function of deuteron. Expression for Pd.

Review of nuclear forces - charge, Symmetry, spin-dependence, tensor character, exchange character. Pseudoscalar meson theory. General survey of non-central forces. Two body potential, three body and many body potentials [13 hrs]

Unit IV Scattering [13 hrs]

Free n-p and p-p scattering - n-p scattering formalism - partial wave analysis - theory of S wave neutron scattering by free protons - scattering length - spin dependence of n-p scattering. Effective range theory of n-p scattering - significance of sign of scattering length - coherent and incoherent scattering. Coherent scattering from hydrogen molecules and sign of scattering lengths. Cross sections for ortho and para hydrogen - comparison with experiment. The optical theorem. Low energy scattering of protons by protons. Mott"s modification of Rutherford formula. Experimental results. Effective range theory for p-p scattering. Analysis of n-p and p-p scattering at low energy. High energy n-p and p-p scattering and experimental results. Photo disintegration of deuteron - dipole approximation cross-section for photo disintegration - photoelectric disintegration cross section and angular distribution studies. [13 hrs]

Text Books:

1. Roy R R and Nigam B P, „Nuclear Physics – Theory and Experiment‟ (Wiley Eastern Ltd., 1993)
2. Emilio Segre, „Nuclei and Particles‟, II Edn. (Benjamin, 1977)
3. Ghoshal S N, „Atomic and Nuclear Physics‟, Vol. II (S Chand & Company, 1994)
4. Singru R M, „Experimental Nuclear Physics‟ (Wiley Eastern, 1972)
5. Curtis L F, „Introduction to Neutron Physics‟
6. Wong, `Introduction to Nuclear Physics‟ (Prentice Hall, 1997)
7. Ponearu D N and Greiner W (ed) „Experimental Techniques in Nuclear Physics‟ (Walter de Gruyter Berlin, 1997)
8. Glaston S, „Introduction to Thermonuclear Reactions‟

Reference Books:

1. Kenneth S Krane, „Introductory Nuclear Physics‟ (John Wiley, 1986)
2. Enge H, „Introduction to Nuclear Physics‟ (Addison Wesley, 1988)
3. Paul E B, „Nuclear and Particle Physics‟ (North Holland, 1969)
4. Evans R D, „Atomic Nucleus‟ (Tata McGraw Hill, 1972)
5. Kapoor S S and Ramamoorthy V S, „Radiation Detectors‟ (Wiley Eastern, 1986)
6. Burcham W E, „Nuclear Physics‟, II Edn. (Longman, 1963)
7. Siegbahn Kai, Alpha, Beta & Gamma Spectroscopy‟, Vol. I, II (North Holland, 1979)
8. Marmier D and Sheldon E, „Nuclear Physics‟, Vol. I, II (Academic Press, 1969)

PHE 509: RADIATION SOURCES AND HAZARDS (open elective) [39 hrs.]

Learning Objectives:

- To provide good knowledge of Radiation Sources, Gamma chamber, Particle Accelerators.
- To introduce radiation biophysics, basic aspects of cell biology and physiology.
- To familiarize Radiation hazard, evaluation, control and radiation protection.
- To study radiation protection standards

Course Outcome (CO)

CO1 The student will have a good knowledge of Radiation Sources, Gamma chamber, Particle Accelerators.

CO2 Will know about radiation biophysics, basic aspects of cell biology and physiology.

CO3 Will have a good understanding of Radiation hazard, evaluation, control and radiation protection.

CO4 Will have good understanding of radiation protection standards.

Unit I Radiation Sources, Gamma chamber, Particle Accelerators – DC accelerators, Linac, Cyclic accelerators, Synchrotron Radiation Sources. Accelerator as photon, neutron and other particle sources. Accelerators in medical and industrial applications. Safety aspects of accelerators. [13 hrs]

Unit II Radiation biophysics Basic aspects of cell biology and physiology. Mechanism of direct and indirect action of radiation at cellular level. Nature of radiation damage at molecular, subcellular and cellular level. Induction of chromosomal aberrations and its application in biological dosimetry of absorbed radiation. Cell killing and induction of mutations. Physical, chemical and biological modifiers of cellular response. Radiation effects on human beings – deterministic and stochastic effects, Dose limits. [13 hrs]

Unit III Radiation hazard, evaluation, control and radiation protection
Hazard evaluation by calculation, area monitoring, personal monitoring. Detection and measurement of contamination on work surface and person. Methods of decontamination. Planning of medical and industrial radiation installations.

Radiation protection standards: Need for protection, philosophy of radiation protection. ALARA principle. Time, distance, shielding. External and internal exposure. [13 hrs]

Text Books:

1. Attix F H et al, „Radiation Dosimetry", Vol. I, II and III (Academic Press, NY, 1968)
2. Knoll G F, „Radiation Detection and Measurements" (Wiley, New York, 1989)
3. Erich J Hall, „Radiology for the Radiologists", III Edn. (J B Lippincott Company, New York, 1988)
4. Herman Cember, „Introduction to Health Physics" (Pergamon Press, 1983)

Reference Books:

1. Glasstone S, „Source book on Atomic Energy‟ (East West Press, New Delhi, 1975)
2. Greening J R, Bristol, Adam Hilger, „Fundamentals of Radiation Dosimetry‟,(Medical Physics Hand Book 6, 1981)
3. Morgan K Z and Turner J E, „Health Physics‟ (Wiley, NY, 1978)
4. Horowitx Y S, Boca Raton (eds.), „Thermoluminescence and TL Dosimetry‟, Vol. I, II and III, (CRC Press, 1984)
5. Mann W B, Et al, „Radioactivity and its Measurements‟, (Pergamon Oxford, 1980)
6. Dillman L T, et al, „Radionuclide Decay Scheme and Dose Estimation‟ Society of Nuclear Medicine, NY, MIRD Pamphlet No. 10, 1975
7. Taylor L S, „Radiation Protection Standards‟, (CRC Press, Cleveland, Ohio, 1971)
8. Richard F. Mould, „Radiation Protection in Hospitals Medical Sciences Series‟, (Adam Hilger Ltd, Bristol and Boston, 1985)
9. Kenneth R Kase, Bjarngard B E and Attix F H, „The Dosimetry of ionising radiation‟, Vol I & II (Academic Press, 1985 & 1987)
10. Ronald L. Kathren, „Radiation Protection‟, (Adam Hilger Lt, International Publishers Services, 1985)
11. Merril Eisenbud, „Environmental Radioactivity‟, (Academic Press, Orlando, 1987)
12. James E Turner, „Atoms, Radiation & Radiation Protection‟, (Pergamon Press, 1986)

PHP 510 : CONDENSED MATTER PHYSICS - PRACTICALS I

Learning Objectives:

- To familiarise X-ray diffraction pattern, experimental determination of elastic constants of crystals, study the anisotropy in the thermal expansion and thermal conductivity of crystalline solids.
- To provide basics on experimental study of dielectrics and ferroelectric materials.
- To teach the experimental techniques on the determination of optical constants of metals.
- To give an idea about basic experimental study on the characteristics of various optoelectronic devices.

Course Outcome (CO)

CO1 The student will be familiar with analysis of X-ray diffraction pattern, experimental determination of elastic constants of crystals, study the anisotropy in the thermal expansion and thermal conductivity of crystalline solids.
CO2 Student get basics on the experimental study of dielectrics and ferroelectric materials.
CO3 The student study about the experimental techniques on the determination of optical constants of metals.
CO4 They have the basic experimental study on the characteristics of various optoelectronic devices.
CO5 Students will be able to set up new experiments to understand the concepts in Physics.
CO6 Students will understand different techniques in material characterisation.

1. X-ray powder pattern analysis: Indexing, identifying the Bravais lattice, and calculating the lattice parameters.
2. Determination of precise lattice parameter from X-ray powder diffraction pattern.
3. Measurement of magnetic susceptibility by Gouy's method.
4. Determination of the Curie temperature and core losses in ferrite and iron cores.
5. Study of the anisotropic property of thermal expansion of crystalline solids using calcite crystal.
6. Study of the anisotropic property of thermal conductivity of crystalline solids using quartz crystal.
7. Measurement of Curie temperature of ferroelectric materials.
8. Ferroelectric hysteresis loop measurement.
9. Ferromagnetic hysteresis study
10. Estimation of the formation energy of quenched-in vacancy in metals.
11. Measurement of elastic constants of crystals
12. Ionic conductivity study.
13. Determination of the optical constants of metals.
14. Transmission line method (TLM) measurement of metal/semiconductor contact resistance.
15. Measurement of absolute thermopower of metals
16. Lattice vibrations – electrical analog
17. Characteristic of phototransistors
18. Liquid crystals phase transitions and texture
19. Optical anisotropy (birefringence) of the nematic liquid crystals.
20. Hall effect study in metals
21. Surface Resistivity and Surface Resistance Measurements Using a Concentric Ring Probe Technique

PHP 511: ELECTRONICS –PRACTICALS I

Learning Objectives:

- To demonstrate design and performance of various electronic amplifier circuits.
- To provide expertise in experiments related to IC 311 comparator – window detector, frequency multiplication using PLL565.
- To teach the design of phase shifter using opamp and precision voltage reference.

Course Outcome (CO)

CO1 Will be able to design and study the performance of various electronic amplifier circuits.
CO2 Student will have the experimental expertise in IC 311 comparator – window detector, frequency multiplication using PLL565.
CO3 Will be able to design phase shifter using opamp and precision voltage reference.
CO4 Students will get ideas to set up new experiments.
CO5 Students will get ideas to fabricate electronic devics.
CO6 Students will get motivation to take up research in electronics.

1. Two stage CS amplifier
2. Cascode amplifier
3. Complimentary symmetry push - pull power amplifier
4. IC 311 comparator – window detector
5. Full wave precision rectifier with equal resisters
6. Frequency multiplication using PLL565
7. Phase shifter using opamp
8. Precision voltage reference

PHP 512: NUCLEAR PHYSICS – PRACTICALS I

Learning Objectives:

- To provide basic understanding of radioactive decay
- To teach how to verify Z-dependence on the absorption of beta rays
- To discuss feather analysis technique of finding end point energy of beta particles
- To discuss energy calibration and resolution of GRS.
- To make student understand attenuation of gamma rays by different materials.
- To teach how to verify inverse square law of radiation.

Course Outcome (CO)

CO1 Understand the random nature of the radioactive decay
CO2 Verify the Z dependence on the absorption of beta rays
CO3 Find the end point energy of beta particles by feather analysis
CO4 Learn energy calibration and resolution of GRS
CO5 Understand the attenuation of gamma rays by different materials
CO6 Verify the inverse square law of radiation.

1. Random nature of radioactive decay
2. Z dependence on the absorption of beta rays
3. End point energy of beta particles - Feather analysis
4. End point energy of beta particles – Nomogram method
5. Energy calibration and resolution of GRS
6. Attenuation of gamma rays
7. Photoelectric absorption cross section
8. Verification of inverse square law
9. Efficiency of alpha counting system
10. Rest mass energy of electron
11. Dead time of a GM counting system
12. Range of alpaha particles in air
13. Data analysis.

PHP 513: CONDENSED MATTER PHYSICS - PRACTICALS II

Learning Objectives:

- To teach resistivity measurement techniques like four-point probe and van der Pauw techniques, demonstrate the magnetoresistance effect in semiconductors, Hall effect using Hall bar and van der Pauw geometry.
- To demonstrate experimental setup for electrical study of samples of high and low resistivity.
- To make students able to estimate the energy gap of semiconductors with simple experiments like current-voltage characteristic of the semiconductor diode, optical absorption or photoconductivity of semiconductor thin films.
- To make students able to determine p-n junction properties by capacitance voltage measurement.
- To demonstrate the determination of thermoelectric properties of thin films and nanostructures.

Course Outcome (CO)

CO1 To the study the properties of semiconductor using resistivity measurement techniques like four-point probe and van der Pauw techniques, demonstrate the magnetoresistance effect in semiconductors, Hall effect using Hall bar and van der Pauw geometry.
CO2 The student will able to setup experiments for electrical study of samples of high and low resistivity.
CO3 Will be able to estimate the energy gap of semiconductors with simple experiments like current-voltage characteristic of the semiconductor diode, optical absorption or photoconductivity of semiconductor thin films.
CO4. Student will be able to determine p-n junction properties by capacitance voltage measurement.
CO5 Will be able to study thermoelectric properties of thin films and nanostructures.
CO6 Students will be able to set up new experiments.

1. Hall effect study in semiconductors
2. van der Pauw method of resistivity and Hall voltage measurement in semiconductors.
3. Determination of Fermi energy of metals
4. Thermionic emission study in metals.
5. Determination of energy gap of a semiconductor using p-n junction diode
6. Measurement of capacitance voltage characteristic of the given p-n junction diodes
7. Measurement of current voltage characteristic of a photodiode.
8. Measurement of current voltage characteristic of a solar cell.
9. Determination of energy gap of a given semiconductor by temperatures dependent four probe resistivity measurement.
10. Photoconductivity measurement in semiconductors
11. Measuring band gap of semiconductors by optical absorption method.
12. Determining the transition temperature of a high-temperature superconductor
13. Objects Determination phase diagram of binary alloys
14. Temperature dependent Hall measurement in semiconductors.
15. Electron spin resonance study
16. Differential thermal analysis
17. Conductivity measurement in polymers
18. Electroluminecence spectra of LEDs.
19. Calibration of thermal sensors

PHP 514: ELECTRONICS –PRACTICALS – II

Learning Objectives:

- To demonstrate amplitude modulation and demodulation,
- To show frequency synthesis and frequency shift keying (FSK) generator using PLL565.
- To familiarize with technique of re-emphasis and de-emphasis.
- To make students able to perform frequency modulation and demodulation using appropriate ICs.
- To make students able to perform pulse width modulation and pulse code modulation.

Course Outcome (CO)

CO1 Will be able to perform amplitude modulation and demodulation,
CO2 would be able to perform frequency synthesis and frequency shift keying (FSK) generator using PLL565.
CO3 Will know the technique of re-emphasis and de-emphasis.
CO4 Able to perform frequency modulation and demodulation using appropriate ICs.
CO5 Able to perform pulse width modulation and pulse code modulation.
CO6 Able to perform frequency shift keying using ICs.

1. Amplitude modulation
2. Demodulating AM voltage
3. PLL565 – Frequency synthesis
4. Frequency modulation and demodulation using IC 8038 and 560
5. Pulse width modulation
6. Frequency shift keying using PLL565
7. Pre-emphasis and de-emphasis
8. Pulse code modulation

PHP 515 : **NUCLEAR PHYSICS – PRACTICALS II**

Learning Objectives:

- To teach Design and verify two stage FET amplifier
- To demonstrate construction bistable multivibrator
- To familiarise Construction and verification of coincidence and anticoincidence circuit
- To discuss design and construction of linear pulse amplifier
- To demonstrate construction of monoshot using IC
- To teach verification of zero crossing detector
- To demonstrate construction and working of Flash ADC

Course Outcome (CO)

CO1 Design and verify two stage FET amplifier
CO2 Construct bistable multivibrator
CO3 Construct and verify coincidence and anticoincidence circuit
CO4 Design and construct linear pulse amplifier
CO5 Construct monoshot using IC
CO6 Verify zero crossing detector
CO7 Construct and understand the working of Flash ADC

1. Two stage FET amplifier
2. Bistable multivibrator
3. Coincidence circuit (discrete components)
4. Anticoincidence circuits (discrete components)
5. Linear pulse amplifier
6. Monoshot using ICs.
7. Zero crossing detector
8. Pulse stetcher
9. Flash ADCS
10. Data analysis using PC
11. Phase shifter using OPAMP
12. Pulse recorder
13. Pulse discriminator using IC
14. Display devices
15. Window Detector
16. Pulse shaping circuits
17. R-2R D/A converter

PHH 551: LASER PHYSICS, VACUUM TECHNIQUES AND CRYOGENICS [**52 Hrs.**]

Learning Objectives:

- To make students able to deal with lasers for variety of applications as the theory part is dealt with effectively.
- To teach non-linear optics
- To discuss vacuum technique-based experiments.
- To introduce holography
- To discuss various cryogenic techniques to make students ready for cryogenic industry related employments with basic knowledge on the topics.

Course Outcome (CO)

CO1 On completion of this course, the candidate would be able to deal with lasers for variety of applications as the theory part is dealt with effectively.

CO2 All the fields having laser applications would be easier for the candidate to understand after studying this part of the course.

CO3 The candidate to understand any vacuum technique-based experiments.

CO4 The knowledge of vacuum systems is useful in food processing and packaging industries where the tightness of a package is often tested under vacuum and the equipment employed for food analysis is always operated with vacuum pumps

CO5 The study on cryogenics would help students to understand the behavior of materials in very low temperature.

CO6 Will help students to take up jobs in cryogenic industries.

Unit I Lasers and non-linear optics

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 - CO_2 laser - Semiconductor lasers - dye lasers - chemical lasers - X ray lasers, free electron laser, Q switching. [13 hrs]

Unit II Holography and Non-linear optics

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. [13 hrs]

Unit III Vacuum techniques

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. Vacuum feedthroughs - vacuum valves (diaphragm valve, slide valve, ball valve). [13 hrs]

Unit IV Cryogenic techniques

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. [13 hrs]

Text Books:

1. Silfvast W T, „Laser Fundamentals‟ (Cambridge University Press, 1998)
2. Ghatak A K and Thyagarajan, „Optical Electronics‟ (Cambridge University Press 1991)
3. Laud B B, „Lasers & Nonlinear Optics‟ (Wiley Eastern, 1985)
4. Mills D L, „Nonlinear Optics – Basic Concepts‟ (Narosa Publishing, 1991)
5. Roth A, `Vacuum Technology‟, II Edn. (North Holland, 1982)
6. Barron R F, `Cryogenic Systems‟ II Edn. (Oxford University Press, 1985)
7. Wilks J and Betts D S, `An Introduction to Liquid Helium‟ (Oxford University Press, 1987)

Reference Books:

1. Shen Y R, „The Principles of Nonlinear Optics‟ (John Wiley, 1984)
2. Boyd R W, „Nonlinear Optics‟ (Academic Press, 1992)
3. Zernike F & Midwinter, „Applied Nonlinear Optics‟ (Wiley, 1973)
4. Oshea D C, Callen W R & Rhodes W T, „Introduction to Lasers & Their Applications‟ (Addison Wesley, 1977)
5. Harris N S, `Modern Vacuum Practice‟ (McGraw Hill, 1989)
6. O‟Hanlon J F, `A User‟s Guide to Vacuum Technology‟ (John Wiley, 1980)
7. West C D, `Principles and Applications of Stirling Engines‟ (Van Nostrand Reinhold, 1986)

PHH 552 ASTROPHYSICS AND RELATIVITY **[52 Hrs.]**

Learning Objectives:

- To teach basic terminologies used in Astrophysics
- To familiarize with energy generation and importance of HR diagram.
- To provide basics of astrophysics so as to make students prepared to pursue research in future.
- To review special theory of relativity
- To introduce general theory of relativity.
- To provide basics of astrophysics so as to make students prepared to pursue research in future.
- To provide basics of relativity so as to make students prepared to pursue research in future.

Course Outcome (CO)

CO1 The student will have good understanding of basics of astrophysics
CO2 Good understanding of energy generation in stars
CO3 Will have sufficient basics to pursue research in astrophysics in future.
CO4 will be able to explain special theory of relativity.
CO5 Will be well versed with general theory relativity
CO6 Will have sufficient basics to pursue research in relativity in future.

Unit I Astrophysics

Astronomical instruments: Hubble Space Telescope, Photometry, detectors and image processing.

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. Stellar positions and motions. Measurement of stellar distances – method of heliocentric parallax, statistical parallax method, apparent luminosity method, spectroscopic parallax method. Variable star distances. Nova distances. [13 hrs]

Unit II Energy generation in stars. Contents of milkyway 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. [13 hrs]

Unit III Theory of relativity

Special theory: review – postulates of special theory of relativity, relativity of simultaneity and Lorentz transformation equation of lengths perpendicular and parallel to relative motion; time intervals, transformation of velocities and acceleration. Stellar aberration. Doppler effect. Relativistic force law and dynamics of single particle. Equivalence of mass and energy.

4 dimensional formulation of theory of relativity - Lorentz transformation, length contraction, time dilation, covariance of laws of nature. 4-dimensional line element. 4 velocity, 4 acceleration, 4 momentum and 4 force. Fundamental equations of motion of a particle in 4-dimensional vector form.

Inertial and gravitational mass. Eotvos experiment. [13 hrs]

Unit IV General relativity

Tensor calculus – Christoffel symbols – covariant differentiation of tensors – the equation of geodesic line – the Riemann – Christoffel tensors – transformation laws for the Christoffel symbols. Stress-Strain tensors – Maxwell‟s equation in tensor form.

Principles of equivalence and covariance. Schwarzschild line element. Schwarzschild radius. Tests for the theory of relativity – Advance of perihelion, light trajectory in a Schwarzschild field, gravitations shift of spectral lines. Experiment of Rebka and Pound. [13 hrs]

Text books:

1. Introduction to Astrophysics „Baidyanath Basu‟ (PHI, 1997).
2. Michael Feilik and John Gaustad „Astronomy the Cosmic Prospective‟ (John Wiley & Sons, Inc., 1990)
3. Resnik R, „Introduction to Special Relativity‟ (Wiley Eastern, 1972)
4. Rindler W, „Introduction to Special Relativity‟, II Edn. (Oxford University Press, 1991)

Reference Books:

1. Schutz B F, „A First Course in General Relativity‟ (Cambridge University Press, 1985)
2. Feilik M, „Astronomy – the Evolving Universe‟ III Edn (Harper and Row, 1982)
3. Boris A Vorontsov-Vel‟yaminov, „Essay about the Universe‟ (Mir Publishers, Moscow, 1985)
4. French A P, „Special Relativity‟ (Thomas Nelson, 1968)
5. Moller C, Theory of Relativity II Edn. (Claredon Press, 1972)
6. Jean-Pierre-Luminet „Black Holes‟ (Cambridge University Press, 1987)
7. D Mc Gillivray „Physics and Astronomy‟ (McMillan, 1987)
8. Michael Berry „Principles of Cosmology and Gravitation‟ (Cambridge University Press, 1976)
9. Rosser W G V, „An Introduction of the Theory of Relativity‟ (ELBS – Butterworth, 1972)
10. Lord EA, Tensorl, Relativity and Cosmology‟ (Tata McGraw Hill, 1976)
11. Ray d‟Inverno, „Introducing Einstein‟s Relativity‟ (Oxford University Press, 1992)
12. Dixon W G, „Special Relativity, the Foundation of Modern Physics‟ (Cambridge University Press, 1978)

13. Adler R, Bazin M & Schiffer M, „Introduction to General Relativity‟, II Edn. (McGraw Hill, 1975)
14. Hughston L P and Tod K P, „An Introduction to General Relativity‟ (Cambridge University Press)
15. Hans Stephani, „General Relativity‟ II Edn. (Cambridge University Press, 1990)
16. Peter Gabrial Bergmann „Introduction to theory of Relativity‟ (PHI, 1989)
17. Nigel Henbest and Heather Couper „The Restless Universe‟ (George Philip, 1982)
18. Jagjit Singh. „Great Ideas and Theories of Modern Cosmology‟ (Dover Publications, Inc., 1961)
19. Marc L Kutner " Astronomy a physical perspective (2^{nd} edition) Cambridge University Press 2003.

PHS 553 : CONDENSED MATTER PHYSICS III **[52 Hrs.]**

Learning Objectives:

- To teach ferromagnetism and applications.
- To familiarize anti-ferro and ferrimagnetism
- To discuss Paramagnetic relaxation and Magnetic resonance
- To provide detailed knowledge of nanomaterials and nanostructures.
- To provide sufficient knowledge of nanomaterials and structures which would enable the students to gain employment in R&D laboratories and in industry.

Course Outcome (CO)

CO1 On completion of this course, the candidate would be able to deal with ferromagnetism and applications.

CO2 On completion of this course, the candidate will have an understanding of anti-ferro and ferrimagnetism

CO3 The candidate will be well versed in Paramagnetic relaxation and Magnetic resonance

CO4 The candidate will have a sound knowledge of nanomaterials and nanostructures.

CO5 The knowledge of nanomaterials and structures would enable the students to gain employment in R&D laboratories and in industry.

CO6 Students will get ideas to setup new experiments.

Unit I Ferromagnetism

Introduction. Classical molecular field theory and comparison with experiment. Heisenberg exchange interaction. Ising model of ferromanetism. Spin waves and magnons. Bloch $T^{3/2}$ law. Band model theories ferromagnetism. Crystalline anisotropy. Ferromagnetic materials. Magnetization of ferromagnetic materials. Ferromagnetic domains, single-domain ferromagnetic particles. Superparmagnetic particles, Domain walls. Domain structure, transition region between domains. Analysis of the magnetization of bulk materials, Soft magnetic materials, Ferromagnetic thin films, Neutron diffraction in magnetic structure analysis. [13 hrs]

Unit II Antiferro and ferrimagnetism

Molecular field theory of antiferromagnetism: Neel temperature, susceptibility below Neel temperature, application of the molecular filed theory for antiferromagntic arrangement of atomic moments in body-centred and face-centred cubic lattice, experimental results of susceptibility for antiferromagnetic compounds. Antiferromagnetic magnons, Indirect exchange interaction. Antiferromagnetic materials. A, C and G types of antiferromagnetic materials. Dzyaloshinskii–Moriya interaction (qualitative), Helimagnetism.

Molecular field theory for ferrimagnetic materials: paramagnetic region, the ferrimagnetic Neel temperature, spontaneous magnetization. Spinels and garnets. Introduction to magnetic bubbles, formation and structures of magnetic bubbles, basic properties of magnetic bubbles, and bubble domain materials. [13 hrs]

Unit III Paramagnetic relaxation and Magnetic resonance

Thermodynamics of magnetization. Paramagnetic susceptibility in an alternating magnetic field. Paramagnetic relaxation mechanism and relaxation times. Spin-lattice relaxation in a two-level system. Relation between the susceptibility at high frequencies

and the spin-lattice relaxation time using thermodynamic considerations.
Paramagnetic resonance: Conditions required for paramagnetic resonance absorption. Illustration of the principle of paramagnetic resonance using equation motion of magnetic dipole. Description of paramagnetic resonance using Bloch equations. Electronic paramagnetic/spin resonance, Fine and hyperfine structure in electron resonance. Crystal filed splitting and the electron paramagnetic resonance of transition group ions. ESR spectrometer.
Nuclear paramagnetic resonance/nuclear magnetic resonance (NMR): Introduction. Illustration of nuclear magnetic resonance classical equation of nuclear magnetic dipole in the rotating coordinate system. Bloch equations. Solutions of the Bloch equations weak RF filed. NMR line shape and line width. Resonance in nonmetallic solids. Influence of nuclear motion on line widths and relaxations. Chemical shift. Quadrupole effect in NMR. NMR instrumentation.
Ferromagnetic resonance. Introduction, shape effects in ferromagnetic resonance.
[13 hrs]

Unit IV Nanomaterials and nanostructures
Introduction. Properties of materials at nanoscale. Synthesis of nanomaterials by top-down approaches: Mechanical attrition, lithography, and micromachining.
Bottom-Up approach of nanoparticle synthesis:
Liquid phase methods: Colloidal methods: Basic aspects of colloids. Homogeneous nucleation and growth of nanoparticles. Synthesis of metal and semiconductor nanoparticles. Surfactants and size-controlled synthesis of nanoparticles. Synthesis of oxide nanoparticles by colloidal sol-gel process. Hydrothermal synthesis. Polyol method. Sonochemical, microwave and micro-reactor synthesis.
Solution phase synthesis of nanoparticles through heterogenous nucleation: Fundamentals of heterogeneous nucleation, Synthesis inside micelles or using microemulsions, Synthesis of epitaxial core-shell nanoparticles.
Gas-phase synthesis of nanoparticles: Inert gas condensation, pulsed laser ablation, laser pyrolysis, flame pyrolysis, sputtering, Atomic layer deposition, Molecular Beam Epitaxy (MBE). chemical vapor synthesis, Metal-organic Chemical Vapor Deposition (MOCVD), electric arc deposition.
Synthesis of one-dimensional nanostructures: Vapour phase methods. Template-based electrodeposition, colloid dispersion, melt synthesis. Electrospinning.
Synthesis of carbon nanotubes and graphene. Synthesis of nanomaterials using lithography, nanolithography, soft lithography, nanomanipulation using scanning probe microscopic methods.
Structural, morphological, Chemical and optical characterization of nanomaterials.
Applications of Nanomaterials in electronic and optoelectronic devices, in catalytic, and medical field. [13 hrs]

Text Books:

1. A. H. Morrish, „The Physical Principles of Magnetism" (Robert E Kreiger, 1980)
2. J. Crangle, Solid State Magnetism" (Edmond-Arnold, 1991).
3. C. Kittel, „Introduction to Solid State Physics", 4^{th} to 8^{th} Edition.
4. A. J. Dekker, „Solid State Physics" (Macmillan India)
5. C. P Slichter „Principles of Magnetic Resonance" (Springer, 1996).
6. G. Cao, Nanostructures & Nanomaterials: Synthesis, Properties & Applications" (Imperial College Press in 2004 and World Scientific, 2011).
7. Sulabha K. Kulkarni, Nanotechnology principles and practices, (Capital Publishing Company, New Delhi, 2014).
8. Risal Singh and Shipra Mital Gupta, Introduction to nanotechnology (Oxford

University Press, 2016).
9. K. K. Chattopadhyay and A. N. Banerjee, Introduction to nanoscience and Technology, (PHI, 2019).
10. C. P. Poole and F. J. Owens,Introduction to Nanotechnology‟ (Wiley, 2006).
11. P. I. Varghese, T. Pradeep, A text book of Nanoscience and Nanotechnology (Tata McGraw-Hill Education, 2003)
12. Magnetic bubble domains, G. A Jones, Sci. Prog., Oxf. (1976) 63, 219-240.

Reference Books:

1. Ibach H & Luth H „Solid State Physics‟ II Edn. (Springer, 2000)
2. K. Yosida, „The Theory of Magnetism‟ (Springer, 1998).
3. Ashcroft N W and Mermin N D, „Solid State Physics‟ (Harcourt, 1976)
4. Rogalski M S and Palmer S B „Solid State Physics‟ (Gordon & Breach, 2000)
5. Yury Gogotsi Ed., „Nanomaterials Hand Book‟ (CRC Press, Taylor & Francis Group, 2006)

PHS 554: ELECTRONICS III **[52 Hrs.]**

Learning Objectives:

- To review binary and hexadecimal number system
- To teach 8085 microprocessor architecture in detail.
- To discuss how to program 8085 microprocessor.
- To make students able to write programs with Stack and subroutines,
- To provide knowledge of 16 bit microprocessors.
- To provide knowledge of 8051 Microcontrollers.

Course Outcome (CO)

CO1 The candidate will have the knowledge on 8085 microprocessor architecture.
CO2 The candidate will be able program 8085 microprocessor.
CO3 Will be able to write programs with Stack and subroutines,
CO4 Will have knowledge of 16 bit microprocessors.
CO5 Will have knowledge of 8051 Microcontrollers.
CO6 Students will get motivation to fabricate gadget using microprocessor and microcontroller.

Unit I Review of binary and hexadecimal number system - negative number representation. Basic structure of computer systems – Difference between Processors & Controllers, Microprocessors, Single chip micro controller system. Introduction to CPU architecture and interfacing the devices, Instruction classification, instruction, data format and storage. Evolution of microprocessors, historical background, overview of 8086 (till intel i series), architecture - register organization – Memory, input and output devices.
Memory and its classifications, Architecture of processor/controller based system, Von-Neuman & Harvard architecture, RISC & CISC processors. [13 hrs]

Unit II **ARM Processor:** Introduction to processor design, ARM architecture- Programmers model, Pipelining, ARM organization & Implementation, addressing modes, Instruction set, thumb model, advanced microcontroller bus architecture (AMBA), Introduction to ARM Cortex M3 and OMAP L138. [13 hrs]

Unit III **Programming and Interfacing with ARM7 Processor:** Introduction to LPC2148, Block diagram, Memory mapping and accelerator module, Pin details, basic programming, GPIO programming, Timer programming, PWM, Watch Dog Timer, ADC, DAC. Applications- Interfacing of DC & Stepper Motor, LED, Toggle Switch, Matrix Key board. [13 hrs]

Unit IV **8051 Microcontrollers:** Architecture- Input / Output pins, ports and circuits, External memory, Instruction set of 8051 Microcontrollers, Addressing modes, Programming of 8051 microcontrollers, counter & timers, I/O port programming, Serial Data Input/Output, Interrupts. [13 hrs]

Reference Books:

1. Hall D V, „Microprocessors and interfacing, programming and hardware", II Edn. (Tata McGraw Hill, 1992)
2. Steve Furber "ARM System-on- Chip Architecture", Second Edition , Pearson Education, 2000.

3. J.R.Gibson "ARM Assembly Language-an Introduction" Dept. of Electrical Engineering and Electronics, The University of Liverpool, 2007
4. Andrew N.Sloss, Dominic Symes, Chris Wright, "ARM System Developer's Guide" , Elsevier,2004
5. Mazidi M A & Mazidi J G, „The 8051 Microcontroller", (Pearson Education Asia, 2001).

PHS 555: NUCLEAR PHYSICS III **[52 Hrs.]**

Learning Objectives:

- To familiarize students with various nuclear models and study each model in detail
- To make students able to solve conceptual problems on nuclear models
- To teach nuclear reactions in detail.
- To provide good understanding of Born approximation.
- To provide sufficient theoretical background which will help students who pursue research in the topics discussed under this course.

Course Outcome (CO)

CO1 The student will know about various nuclear models.
CO2 The students will be able to solve conceptual problems on nuclear models
CO3 The student will know about Nuclear reactions
CO4 Will have good understanding of Born approximation
CO5 Students will get good understanding on perturbation approach in evaluation of nuclear reaction cross section.
CO6 will have sufficient theoretical background which will help students who pursue research in the topics discussed under this course.

Unit I Nuclear models

Fermi gas model: kinetic energy for the ground state-asymmetry energy - nuclear evaporation.

Independent particle model: motion in mean potential, energy levels according to harmonic oscillator potential and infinite square well potential - effect of spin-orbit interaction.

Prediction of ground state spin, parity of odd-A nuclei and odd-odd nuclei - magnetic moments of odd-A nuclei and quadrupole moment. [13 hrs]

Unit II Nuclear shell model

Shell model for one nucleon outside the core-configurations for the excited states. Model for two nucleons outside the core. Residual interaction - ^{18}O Spectrum (qualitative) for two particles in $d_{5/2}$ orbit and in $d_{5/2}$ - $s_{1/2}$ orbits.

Collective model: collective vibrations and rotations. Nuclear quadrupole moments. Nilsson model - calculation of energy levels - prediction of ground state spin. [13 hrs]

Unit III Nuclear reactions: Background information for nuclear reaction, cross-sections, gross-structure problem, features of direct reaction model and compound nucleus model. Optical model- forms and features of optical potential.

Partial wave approach: partial wave analysis of nuclear reactions-expressions for scattering and reaction cross sections and their interpretations, total cross section, optical theorem. Resonance theory of scattering and absorption. Breit-Wigner formulae. [13 hrs]

Unit IV Perturbation approach: Determination of nuclear reaction cross section based on perturbation theory, evaluation of cross-section near threshold. Inverse reactions -

principle of detail balance, determination of spin of pions.

Transfer reactions - semiclassical description. Plane wave Born approximation (PWBA) - its predictions of angular distributions – modifications. Distorted Wave Born Approximation (DWBA) (qualitative) - spectroscopic factors and their significance. [13 hrs]

Text Books:

1. Segre E, „Nuclei and Particles‟, II Edn. (Benjamin, 1977)
2. Preston M A and Bhaduri R K, „Structure of the Nucleus‟ (Addison Wesley, 1975)
3. Ghoshal S N, „Atomic and Nuclear Physics‟, Vol. I & II (S Chand & Company, 1996)
4. Roy R K and Nigam P P, „Nuclear Physics - Theory and Experiment‟ (Wiley Eastern Ltd., 1993)
5. Enge H, „Introduction to Nuclear Physics‟ (Addison Wesley, 1988)
6. Sachler G R, „Introduction to Nuclear Reactions‟, II Edn. (Macmillan Press, 1990)

Reference Books:

1. Marmier D and Sheldon E, „Physics of Nuclei and Particle‟, Vol. I & II (Academic Press, 1969)
2. Blatt J M and Weisskopf V F, „Theoretical Nuclear Physics‟ (John Wiley, 1952)
3. Krane K S, „Introductory Nuclear Physics‟ (John Wiley, 1987)
4. Perkins D H, „Introduction to High Energy Physics‟, II Edn. (Addison Wesley, 1982)
5. Soodak H and Campbell B C, „Elementary Pile Theory‟ (John Wiley, 1950)

PHS 556: CONDENSED MATTER PHYSICS IV **[52 Hrs.]**

Learning Objectives:

- To introduce crystal defects
- To introduce thin films and study their characterization techniques in detail.
- To review and study superconductivity in detail.
- To introduce polymer science
- To review and study the basics of liquid crystals.
- To prepare students with sufficient necessary background to pursue research in the topics discussed under this course.

Course Outcome (CO)

CO1 The candidate will have through knowledge of crystal defects

CO2 The candidate will have theoretical and experimental knowledge of thin films

CO3 Will have good understanding of mechanical properties of thin film

CO4 Will would have gained knowledge about superconductivity, about polymers & liquid crystals.

CO5 Students will have sufficient necessary background to pursue research in the topics discussed under this course.

CO6 Students will be motivated to set up new experiments.

Unit I Crystal defects

Imperfections in crystals: classification of defects in crystals. Classification of point defects in crystals. Point defects in elemental crystals, Point defects in ionic crystals. Equilibrium concentration of point defects in elemental crystals. Formation energy of point defects in ionic crystals. Equilibrium concentration of point defects in ionic crystals. Diffusion in ionic crystal, Ionic conductivity in pure and doped halides. Colour centers in ionic crystals. Polorons and excitons in ionic crystals. Luminescence in alkali halide compounds: theory of thermoluminescence and electroluminescence.

Line defects: Dislocations- Burger‟s vector. Stress field of a straight screw and edge dislocations, Observation of dislocations. Influence of dislocations on crystal growth. Planar defects: stacking faults, interfaces and grain boundaries.
[13 hrs]

Unit II Thin films

Introduction. Methods of thin film growth: Physical and chemical vapor deposition methods, and the chemical methods. Physical vapor deposition methods: Thermal evaporation – by resistive and RF heating, electron beam evaporation, pulsed laser deposition, and Molecular beam epitaxy. Sputtering methods- DC and RF magnetron sputtering. Chemical vapor deposition: Typical chemical reactions CVD methods- APCVD, LPCVD. PECVD. Photo CVD, and MOCVD. Atomic Layer Deposition (ALD). Chemical methods: chemical bath method, electro-deposition, sol-gel dip coating and spin coating. Spray pyrolysis.

Nucleation, growth and structure of thin films: Theories of nucleation, nucleation modes. Growth process.

Characterization of Thin Films: Thickness measurement. Structural and morphological characterization, chemical and optical characterization, electrical characterization.
A brief introduction on electrical transport in thin Films. A brief introduction on optical properties of thin films- Reflectance and transmittance of light by thin films. Single layer antireflection coatings.

Applications of thin films in optics, optical and magnetic recording, integrated electronic and optical devices, Band-gap engineering and quantum devices, metallurgical and protective coatings. [13 hrs]

Unit III Superconductivity

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.
One-electron tunneling in superconductor junctions. Cooper-pair tunneling -Josephson effect. AC and DC Josephson effects. Macroscopic Quantum Interference in super conductors. Superconducting Quantum Interference Devices (SQUIDS). DC and AC SQUIDs. Applications of SQUIDs.
High T_C superconductors: Discovery YBCO, Important families of high temperature superconductors. [13 hrs]

Unit IV Materials II : Polymers & liquid crystals

Characteristics of Polymers, Classification of polymers: Based on number of monomers -Homopolymers and Copolymers-some common types of co-polymers. Based on Tacticity. Depending upon Functionality - Linear or straight chain polymer, Branched chain polymer, and network polymer. Based on origin- natural and synthetic polymers. Classification based on molecular forces- elastomers, fibres, thermoplastics, thermosetting.

Polymerization and types of polymerization.
Polymer molecular weight- -number-average molecular weight, weight-average molecular weight. Polymer crystallinity. Applications.
Liquid crystals: Thermotropic and lyotropic. Thermotropic liquids- calamitic (rod-like) and discotic molecular shape (other phases -polycatenar and Banana shaped). Mesophases of calamitic liquid crystals: nematic, smectic (smectic A and Smectic C) and cholesteric phases. Discotic phases of liquid crystals: discotic nematic and discotic columnar types (Discotic Cholesteric Phase). Lyotropic liquid crystals: lamellar, hexagonal and cubic phase. Order parameters of liquid crystalline materials: orientational order (Orientational Order Parameter in Nematics), positional order, and bond orientational order. Orientational order parameter S of liquid crystalline material. Liquid crystal textures. Effect of liquid crystals on polarized light. Electric and magnetic field effects on liquid crystals. Freedericksz Transition. Optical anisotropy (Birefringes) and ferroelectricity in liquid crystals. Construction of liquid crystal displays. Applications of liquid crystals. [13 hrs]

Reference Books:

1. Kittel C, „Introduction to Solid State Physics‟, IV Edn. (Wiley Eastern, 1974), VII Edn. (John-Wiley, 1995)
2. Dekker A J, „Solid State Physics‟ (MacMillan, 1971)
3. Ibach H and Luth H „Solid State Physics‟, II Edn. (Springer, 2000)
4. Ashcroft N W and Mermin N D, „Solid State Physics‟ (Harcourt, 1976)
5. Hass G and Thun R E, „Physics of Thin Films‟, Vol. IV (Academic Press, 1967)
6. Chopra K L „Thin Film Phenomena‟ (Robert E Kreiger, 1979)
7. Goswami A, „Thin film fundamentals‟ (New Age, 1996)
8. Chopra K L and Malhotra L K (Ed) „Thin film Technology and applications‟ (Tata McGraw Hill, 1985)
9. M. Ohring: The Materials science of thin films, (Academic Press, 1992, 2nd Ed. 2002).
10. Tinkham M „Introduction to Superconductivity‟ II Edn. (McGraw Hill, 1996)
11. Gowarikar V R, Vishwanathan N V and Shridhar J, „Polymer Science‟ (Wiley Eastern, 1986)
12. Chandrasekhar S, „Liquid Crystals‟, II Edn. (Cambridge, 1992)
13. Chiaken P and Lubensky T C, „Principles of Condensed Matter Physics‟ (Cambridge, 1995)
14. Rogalski M S and Palmer S B „Solid State Physics‟ (Gordon & Breach, 2000)

PHS 557: ELECTRONICS IV **[52 Hrs.]**

Learning Objectives:

- To provide basics of Optic fiber communication
- To discuss various Optical sources and detectors
- To introduce students to signals and system
- To familiarize students with digital signal processing
- To provide good knowledge of Discrete Fourier transform (DFT)

Course Outcome (CO)

CO1 Good understanding of optic fibre communication.
CO2 Good understanding of optical sources and detectors
CO3 will be able to discuss signals and system
CO4 Good knowledge of digital signal processing
CO5 Good knowledge of Discrete Fourier transform (DFT)
CO6 Will motivate students to take up jobs in electronic industires.

Unit I Optic fibre communication

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). [13 hrs]

Unit II Optical sources

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. [13 hrs]

Unit III Signals and Systems

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. [13 hrs]

Unit IV Digital Signal Processing

Discrete Fourier transform (DFT) and IDFT. 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. [13 hrs]

Reference Books:

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

PHS 558: NUCLEAR PHYSICS IV **[52 Hrs.]**

Learning Objectives:

- To review and study Reactor physics in detail
- To introduce Neutron physics
- To study the basics of nuclear fusion
- To teach the basics of particle physics
- To discuss the basics of QED, QCD and weak interactions
- To prepare sufficient theoretical background in students which help to pursue research in the topics studied under this course.

Course Outcome (CO)

CO1 The student will know about various types of nuclear reactors
CO2 The student will have good understanding of neutron physics
CO3 the students will be able to explain Nuclear fusion.
CO4 The student will know about basics of particle physics
CO5 The student will know about basics of QED, QCD and weak interactions
CO6 the students will have sufficient theoretical background in students which help to pursue research in the topics studied under this course.

Unit I Reactor physics

Fundamentals of nuclear fission – fission fuels. Neutron chain reaction, multiplication factor. Condition for criticality – Breeding phenomena. Different types of reactors – Fusion – Nuclear fusion in stars. Slowing down of neutrons by elastic collisions - logarithmic decrement in energy - number of collisions for thermalisation.

Elementary theory of diffusion of neutrons - spatial distribution of neutron flux (1) in an infinite slab with a plane source at one end and (2) in an infinite medium with point source at the centre. Reflection of neutrons -Albedo.

Slowing down density - Fermi age equation. Correction for absorption - resonance escape probability. The pile equations - Buckling. Critical size for spherical and rectangular piles.

Condition for chain reaction - the Four-factor formula. Thermal neutron reactor - Fast breederreactor. [13 hrs]

Unit II Neutron physics

Classification of neutrons according to their energy - neutron sources. Ultrafast neutrons, slow neutron detection through nuclear reaction and induced radio activity - slow neutron cross section measurements - neutron monochromators.

Nuclear fusion - basic fusion processes - characteristics of fusion - fusion in stars. Controlled thermonuclear reactions. Hydromagnetic equations. magnetic pressure, pinch effect, magnetic confinement systems for controlled thermonuclear fusion. [13 hrs]

Unit III Particle physics

Conservation laws and basic interactions relating to elementary particles - particles and antiparticles, Feynman Diagrams, Cross-section and decay widths
Leptons - neutrinos, muon production and decay - muon capture, spin and magnetic

moments of muons.

Pions - the Yukawa interaction, spin of pions - intrinsic parity - isotopic spin of pions. Pion-nucleon scattering and resonance. Nuclear collision, production and photo production of Pions. [13 hrs]

Unit IV Strange particles and weak interactions

Strange particles: associated production – strangeness quantum number; Gellman-Nishijima formula – Kaons and Lambda, Sigma, Xi and Omega hyperons.

The Quark model – quark composition of particles.

Weak interactions: neutral Kaons. The K - K systems. Regeneration of the short lived component of neutral Kaons. CP violation – the CPT theorem Verification of electromagnetic and weak interactions – intermediate vector bosons.

Introduction to QCD, gluon field and color, Beyond the Standard Model: SUSY, GUTs, Dark Matter.

[13 hrs]

Text Books:

1. Goshal S N, `Atomic & Nuclear Physics‟, Vol. II (S Chand & Company, 1994)
2. Wong, `Introduction to Nuclear Physics‟ (Prentice Hall, 1997)
3. Marmier D and Sheldon E, „Physics of Nuclei and Particles‟, Vol. I, II (Academic Press, 1969)
4. Zweifel P F, „Reactor Physics‟, International student Edn. (McGraw Hill, 1973)
5. Emilio Segre, „Nuclei and Particles‟, II Edn. (Benjamin, 1977)

Reference Books:

1. Kenneth S Krane, Introductory Nuclear Physics‟ (John Wiley, 1986)
2. Glasstone S and Sesonske A, „Nuclear Reactor Engineering‟ (CBS, Delhi, 1986)
3. Little field T A and Thorley N „Atomic and Nuclear Physics‟, II Edn. (Nostrand Co., 1988)