

# **MANGALORE UNIVERSITY**

**DEPARTMENT OF POST GRADUATE STUDIES &  
RESEARCH IN PHYSICS  
MANGALORE UNIVERSITY  
MANGALAGANGOTTHRI 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  
MANGALAGANGOTTHRI**

**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)

**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	$\frac{2 \times 4}{8}$	1	3	-	-	25
IV	2 H	2x4=8	-	-	2 S	$\frac{2 \times 4}{8}$	-	-	1 H	4	20

Total credit from all the four semesters (I, II, III and IV): 22+25+25+20 = 92

**Details of course and credits for four semesters:**

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**

<b>SEMESTER</b>	<b>Theory/practicals</b>	<b>Exam. hours</b>	<b>Marks end Semester + Internal assessment</b>	<b>Credits</b>	<b>Total</b>
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)	3 hrs each	70 + 30* each	2 x 3 = 6	200
	One open elective (theory)	3 hrs	70 + 30* each	1x3 =3	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)	3 hrs each	70 + 30* each	2 x 3 = 6	200
	One open elective (theory)	3 hrs	70 + 30* each	1 x3=3	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)		100	1 x 4 = 4	100
			<b>Grand Total</b>	<b>92</b>	<b>2500</b>

\*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.

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

**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 2016- 2017)

**COURSE PATTERN AND SCHEME OF EXAMINATION**

SEMESTER	Description of the Papers	Teaching Hrs/ week	Credit Hard(H)/Soft(S)/ Open elective(OE)	Max Marks: Exam + IA = Total
<b>I SEMESTER</b>				
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 (Electronics)	6	3 S	70 + 30
<b>II SEMESTER</b>				
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 (General)	6	3 S	70 + 30

<b>III SEMESTER</b>				
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
<b>IV SEMESTER</b>				
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

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 Stokes') and their applications in physics.

Generalized coordinates - elements of curvilinear coordinates - transformation of coordinates - orthogonal curvilinear coordinates - unit vectors - expression for arc length, volume element. The gradient, divergence and curl in orthogonal curvilinear coordinates. Laplacian in orthogonal curvilinear coordinates, spherical polar coordinates, cylindrical coordinates. [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,  $m^{\text{th}}$  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 equation and diffusion equation in Cartesian, plane, cylindrical and spherical polar coordinates. [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. [13 hrs]

#### Text Books:

1. Arfken G, 'Mathematical Methods for Physicists' (Academic Press)
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)
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.]

- 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)

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. Aruldas, (Prentice Hall of India,2008)

**Reference Books**

- 1 Classical mechanics, L. D. Landau and E. M. Lifshitz, (4<sup>th</sup> 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

**Unit I Electrostatics and Magneto statics:**

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 (Cartesian co ordination). Boundary conditions and uniqueness theorem. Method of images and applications. Multipole expansion. Electric dipole field, redo pot, Field inside a dielectric- special problems involving linear dielectric, Biot –Savart law and applications, Ampere's law and applications,

Magnetic vector potential, Boundary conditions. Multipole expansion of vector potential. Review of magnetisation. Magnetic field inside matter, The field of a magnetized object. [13 hrs]

**Unit II Electromagnetic waves:**

Review of Maxwell's equations, formulating electrodynamics using scalar and vector potentials, Gauge transformations. Coulomb gauge and Lorentz gauge. 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 III Electromagnetic Radiation:**

Retarded potentials. Electric and magnetic dipole radiation. Lienard-Wiechert potentials. Fields of a point charge in motion, slowly moving, Power radiated by a point charge oscillation, Larmor formula,

Review of Lorentz transformations, Four vectors, Magnetism as a relativistic phenomenon, Lorentz transformation of electric and magnetic fields, The electromagnetic field tensor notation, potential formulation of electrodynamics. [13 hrs]

**Unit IV Plasma Physics:**

Plasma - definition, Debye shielding distance, hydromagnetic equations. Motion of charged particle in (a) uniform magnetic field (b) electric and magnetic fields at not angled (c) space dependent magnetic field. 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)
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)Classical

## PHP 405: PHYSICS PRACTICALS I (General)

- 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 Susceptibility by Quinke`s method.
- 5 Modes of vibration of a fixed free bar
- 6 Temperature dependence of Hall coefficient.
- 7 Magnetic susceptibility of hydrated copper sulfate.
- 8 To study the variation of magnetoresistance of a sample with the applied magnetic field.
- 9 To determine the strength of an  $\alpha$ -source using SSNTD.
- 10 Transition temperature of a ferroelectric material
- 11 Dielectric constant of a given material.

**\* Additional experiments may be included.**

## **PHP 406: PHYSICS PRACTICALS II (Electronics)**

- 1 Clipping and clamping circuits
- 2 Differentiator & integrator circuits
- 3 Logic gates.
- 4 UJT characteristics - relaxation oscillator.
- 5 Opamp 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.

**\* Additional experiments may be included.**

- 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. [13 hrs]
- Unit III 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 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, 1999)
5. Arfken G, 'Methods of Mathematica Physics, (Academic Press 2005)
6. Kreyszig, Advanced Engineering Mathematics, (New Age International, 2004)

**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. Sreenivasa Rao K N, 'The Rotation and Lorentz Groups and Their Representations for Physicists' (John Wiley & sons, 1988)
6. N.Hammermesh, 'Group Theory', (Addison-Wesley, 1964)
7. M.Tinkham, 'Group Theory and Quantum Mechanics', (McGraw-Hill, 1964)
8. E.Butkov, 'Mathematical Physics', (Addison-Wesley, 1968)
9. P.M.Morse and H.Feshbach, 'Methods of Theoretical Physics', (Interscience, 1953)

## PHH 452: QUANTUM MECHANICS II

[52 hrs.]

- 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 - Clebsch-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 quantisation  
Klein-Gordon equation for a free particle - Dirac equation - Dirac matrices. - spin and magnetic moment of the electron.  
  
Transition from particle to field theory. Second quantisation 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]

### 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. [13 hrs]

Nuclear decay - Alpha decay - quantum mechanical tunnelling - 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).

### 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 [13 hrs]

### Unit III Ionising radiations and applications: Sources of ionising radiations in the environment – terrestrial radiation sources and radionuclides, 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]

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, acceptor 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.)**

### **Unit I**

Renewable energy resources: Energy and Thermodynamics, Forms of Energy, Conservation of Energy, Entropy, Heat capacity, Thermodynamic cycles: Brayton, Carnot Diesel, Otto and Rankin cycle; Fossil fuels, time scale of fossil fuels and solar energy as an option. Solar Energy for Clean Environment Sun as the source of energy and its energy transport to the earth, Extraterrestrial and terrestrial solar radiations, solar spectral irradiance, Measurement techniques of solar radiations, Estimation of average solar radiation **[13 hrs]**

### **Unit II**

Basics of the Wind energy: Wind Energy Origin and classification of winds, Aerodynamics of windmill: Maximum power, and Forces on the Blades and thrust on turbines; Wind data collection and field estimation of wind energy, Site selection, Basic components of wind mill, Types of wind mill, Wind energy farm, Hybrid wind energy systems: The present Indian Scenario. **[13 hrs]**

### **Unit III**

Biomass energy and biogas technology: Nature of Biomass as a fuel, Biomass energy conversion processes, Direct combustion: heat of combustion, combustion with improved Chulha and cyclone furnace; Dry chemical conversion processes: pyrolysis, gasification, types of gasification Importance of biogas technology, anaerobic decomposition of biodegradable materials, Factors affecting Bio-digestion, Types of biogas plants, Applications of biogas. **[13 hrs]**

### **References**

1. Peter A., 'Advances in energy systems and technology', (Academic Press, USA, 1986).
2. Neville C.R., 'Solar energy conversion: The solar cell', (Elsevier North-Holland, 1978).
3. Dixon A.E. and Leslie J.D., 'Solar energy conversion', (Pergamon Press, New York, 1979).
4. Ravindranath N.H., 'Biomass, energy and environment', (Oxford University Press, 1995).
5. Cushion E., Whiteman A. and Dieterle G., (World Bank Report, 2009).

### **PHP 456 PHYSICS PRACTICALS III (General)**

1. Half life of K-40
2. Thermoelectric constant
3. Gamma ray Spectrum of Cs-137
4. Ferroelectric Curie temperature
5. Estimation of effect of white light (sun tracking) on energy generation by solar PV module.
6. To measure the variation of dielectric constant with temperature and verification of Curie Weiss law.
7. Verification of Inverse square law (G.M.tube)
8. Transition temperature of ferrites.
9. Temperature dependence of Hall coefficient.
10. To study the I-V characteristics of solar panel.
11. Study of Hall effect
12. To measure the variation of dielectric constant with temperature and verification of Curie Weiss law.

**\* Additional experiments may be included.**

#### **PHP 457: PHYSICS GENERAL PRACTICALS IV**

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

**\*Additional experiments may be included.**

## PHH 501: ATOMIC AND MOLECULAR PHYSICS

(52 Hrs.)

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 - Experimental technique – Microwave spectrometer, structural information. Microwave oven.

Theory of vibrating rotator, vibration - rotation spectra, IR spectrometer. Application in chemical 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)
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.)

- Unit I Thermodynamics: Concept of entropy - principle of entropy increase - entropy and disorder. Enthalpy - Helmholtz and Gibbs' functions. Maxwell's relations - TdS equations - energy equations - Heat capacity equations - heat capacity at constant pressure and volume. Phase space and ensembles - Liouville's theorem, probability - thermal equilibrium. [13 hrs]
- Unit II Classical statistics: Boltzmann distribution, calculation of velocities - average and r.m.s velocities Gibbs' paradox, Sackur - Tetrode equation, partition functions - translational partition function, vibrational, rotational and electronic partition functions. Boltzmann equipartition theorems. Application to specific heats. [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.
- 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.
- 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)

**Unit I Crystallography**

Symmetries elements, translations vectors – screw axes and glide plane symmetries. Space groups – illustrations, Concept of point groups, Influence of symmetry on physical properties, derivation of equivalent point positions (with examples from triclinic and monoclinic systems), experimental determination of space group. Disordered solid structure - Amorphous solid, quasi crystal and liquid crystal.[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. Bruschi 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.
11. Solid State Physics: An Introduction to Theory and Experiment by H. Ibach and H.
12. Luth.
13. Principles of the Theory of Solids (2nd edition) by J. M. Ziman

## PHS 504 : ELECTRONICS I

(52 Hrs.)

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

IC fabrication technologies - wafer preparation - chemical vapour deposition - diffusion - ion implantation – photolithography. Fabrication of resistors, capacitors, BJT and MOS devices [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. Henry W Ott, 'Noise Reduction Techniques in Electronic Systems' (John Wiley, 1989)
3. Jaspreet Singh, 'Semiconductor Devices' (McGraw Hill, 1994)
4. Boylestad R & Nashelsky L, 'Electronic Devices and Circuit Theory' VIII Edn. (PHI, 2002)
5. Coughlin R F & Driscoll F F, 'Operational Amplifiers and Linear Integrated Circuits', VI Edn. (Pearson Education Asia, 2002).

6. Gayakwad R A, 'Opamps and Linear Integrated Circuits' IV Edn. (PHI, 2002)
7. 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.)

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. HPGGe 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'
7. Wallemar Scharf 'Particle Accelerators and their uses' (Harwood Academic 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.)

### Unit I Band theory of solids

Bloch theorem. Nearly Free electron approximation. Tight binding approximation. Applications of the tight binding method to cubic crystals: width of energy bands, the effective mass of electrons in a simple cubic lattice based on tight binding approximation. The shape of constant surfaces and Fermi surfaces, Density of states curve for the simple cubic lattice. Construction of Brillouin zones for a two-dimensional square lattice. General expression for density of states function and calculation of density of states curve for the simple cubic lattice based on tight binding approximation. Overlapping of energy bands and Jones explanation of structural phase transitions in binary alloys. [13 hrs]

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

### Unit II Transport properties

Boltzmann transport equation. Electrical conductivity. Thermal conductivity, Thermoelectric effects and thermopower power. Scattering of electrons. Temperature variation of electrical resistance. Linearized Boltzmann transport equation. AC conductivity of metals. Hall effect, High field effects and magnetoresistance. Cyclotron resonance. Plasma frequency and plasmons. [13 hrs]

### Unit III Semiconductors I

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

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

Metal semiconductor contacts : Formation of rectifying/ Schottky contacts, Depletion layer, Interface states and Fermi level pinning. Current transport processes, Derivation of ideal current voltage characteristics of schottky diodes based on thermionic emission theory. Capacitance of Schottky diodes. Ohmic contacts. [13 hrs]

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

Degenerate semiconductor. Esaki diode.

Optoelectronic devices: Photodetectors: Introduction. Photoconductor. Photodiodes: P-N and P-I-N Photodiodes. Heterojunction Photodiodes. Metal-Semiconductor Photodiodes. Avalanche photodiodes (APDs). Phototransistors. Quantum well Infra Red Photodetectors (QWIPs). Solar cells. Light emitting diodes. Semiconductor Lasers- Heterostructure and quantum well lasers.

Amorphous semiconductor (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, and 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' (3<sup>rd</sup> Edition, Wiley 2006).
7. B. G. Streetman and S. Banerjee, 'Solid State Electronic Devices' 4<sup>rd</sup> to 6<sup>th</sup> Edition (PHI)
8. P. Bhattacharya, 'Semiconductor Optoelectronic Devices, 2<sup>nd</sup> Edition (PHI, 2009).
9. J. H. Davies, 'The Physics of Low-diemnsional Semiconductors: An Introduction, (Cambridge 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 and Y. Tokura. Taylor & Fransis, 2003).
12. S. R. Elliot, 'Physics of Amorphous Materials, 2<sup>nd</sup> Ed. (Longman Scientific & Technical, London).

## PHS 507 : ELECTRONICS II

(52 Hrs.)

### 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).

**Unit I Nuclear spectroscopy**

Experimental determination of beta interaction. 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.)**

- 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. Horowitz 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. Merrill 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**

1. X-ray powder photograph
2. Birefringence of quartz
3. Elastic constants of crystals
4. Thermal expansion
5. Dielectric constant and Curie temperature of Ferroelectric materials
6. Optical constants of metals
7. Thermal conductivity of insulators
8. Lattice vibrations – electrical analog
9. Characteristic of phototransistors
10. Estimation of Planks constant using LED  
(Additional experiments may be included)

## **PHP 511 : ELECTRONICS –PRACTICALS I**

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 resistors
6. Frequency multiplication using PLL565
7. Phase shifter using opamp
8. Precision voltage reference

## **PHP 512: NUCLEAR PHYSICS – PRACTICALS I**

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. Energy calibration and resolution of GRS
5. Attenuation of gamma rays
6. Photoelectric absorption cross section
7. Verification of inverse square law
8. Efficiency of alpha counting system
9. Rest mass energy of electron

## **PHP 513 : CONDENSED MATTER PHYSICS - PRACTICALS II**

1. Magnetoresistance of semiconductor
2. Hall effect
3. Determination of Fermi energy of metals
4. Thermionic emission
5. Determination of energy gap of a semiconductor using p-n junction diode
6. Capacitance of p-n junction diode
7. Thermoelectric effect
8. Photodetectors
9. Characteristic of solar cell
10. Energy gap by four probe method  
(Additional experiments may be included)

### **Reference Books:**

1. Silsbee R H & Drager J 'Simulation for Solid State Physics' (Cambridge 1997)
2. Jerrard H G & Mc Neill D B 'Theoretical and Experimental Physics' (Chapman & Hall 1960)
3. Wooster W A & Breton A 'Experimental Crystal Physics', II Edn. (Clarendon Press 1970)
4. Wieder H H 'Lab notes on Electric and Galvanomagnetic measurements' (Elsevier 1979).

## **PHP 514: ELECTRONICS –PRACTICALS - II**

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**

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

**PHH 551: LASER PHYSICS, VACUUM TECHNIQUES AND CRYOGENICS (52 Hrs.)**

- 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<sub>2</sub> 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 - Penning 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. O Shea 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.)**

### **Unit I     Astrophysics**

Introduction – constellations, solstices, equinoxes, zodiac, temperature of stars and their classification, visible and invisible astronomy.

Asteroids, Comets and Meteorites.

Doppler effect. Hubble's law. Origin and evolution of solar system. Apparent and absolute magnitudes of stars. Measurement of stellar distances – method of heliocentric parallax, statistical parallax method, apparent luminosity method, spectroscopic parallax method. Variable star distances. Nova distances.[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]

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 Gabriel 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<sup>nd</sup> edition) Cambridge University Press 2003.

## PHS 553 : CONDENSED MATTER PHYSICS III

(52 Hrs.)

### Unit I Ferromagnetism

Classical molecular field theory. Heisenberg exchange interaction. Ising model. Spin waves and magnons. Bloch  $T^{3/2}$  law. Band theory of ferromagnetism. Magnetisation of ferromagnets. Crystalline anisotropy. Domains. Bloch wall. Ferromagnetic materials. Neutron diffraction - magnetic structure. [13 hrs]

### Unit II Antiferro and ferrimagnetism

Molecular field theory. Indirect exchange interaction. Antiferromagnetic materials. Helimagnetism.

Molecular field theory for ferrimagnetic materials. Spinel and garnets. Magnetic bubbles. [13 hrs]

### Unit III Paramagnetic relaxation and Magnetic resonance

Paramagnetic relaxation: Susceptibility in alternating magnetic field. Thermodynamic theory of Casimir and Dupre for spin lattice relaxation. Spin - spin relaxation. Electron paramagnetic resonance: Introduction. Phenomenological theory of resonance. line width, hyperfine structure. Spectra of transition group ions. ESR spectrometer.

Nuclear magnetic resonance (NMR): Elements of the theory of NMR – Bloch equations. Solutions of the Bloch equations weak RF field. NMR line shape and width. Resonance in non-metallic solids. Influence of nuclear motion on NMR line width. Chemical shift. Quadrupole effect in NMR. NMR Experimental aspects. [13 hrs]

Ferromagnetic resonance. Introduction, shape effects in ferromagnetic resonance.

### Unit IV Nanomaterials and nanostructures

Introduction. Physical properties of the materials at the nanoscale:

Melting points and lattice constants. Mechanical properties. Optical properties- Surface plasmon resonance, Quantum size effects in optical absorption and photoluminescence. Electrical conductivity-Surface scattering, Quantum transport. Bottom-Up and Top-Down Approaches of nanomaterials synthesis.

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

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

A brief introduction on carbon fullerenes and nanotubes, graphine, ordered mesoporous materials, organic-inorganic hybrids, intercalation compounds, and oxide-metal core-shell structures.

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

Characterization of Nanomaterials: Structural and morphological characterization. Chemical and optical Characterization.

Applications of Nanomaterials: Molecular Electronics and Nanoelectronics. Band Gap Engineered Quantum Devices. Biological and medical Applications of Nanoparticles, Catalytic applications. Nanomechanics. [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<sup>th</sup> to 8<sup>th</sup> 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. C. P. Poole and F. J. Owens, 'Introduction to Nanotechnology' (Wiley, 2006).

**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.)

- Unit I Review of binary and hexadecimal number system - negative number representation.  
Basic structure of computer systems – Microprocessors, Single chip micro controller system. Introduction to CPU architecture and interfacing the devices. Instruction classification, instruction, data format and storage.  
8085 architecture - register organization – Memory, input and out put devices, Example of microcomputer system. 8085 instruction set – classification.  
Instruction cycle, machine cycle, timing diagram. [13 hrs]
- Unit II Programming with 8085.  
8085 instructions – data transfer, arithmetic, logic and branch operations. Writing assembly language programs. Programming techniques with additional instructions. Counters and time delays. [13 hrs]
- Unit III Stack and subroutines, conditional CALL and RETURN instructions.  
Interrupts – 8085 interrupts – vectored interrupts, software interrupt instructions. [13 hrs]
- Unit IV Peripherals: 8155, 8255, 8254, 8259A, DMA 8237.  
Interfacing data converters – ADC and DAC  
Introduction to 16 bit microprocessors. 8086/8088 [13 hrs]

### Reference Books:

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

**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 -  $^{18}\text{O}$  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, neutron induced reactions, 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, shadow scattering. 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)

**Unit I Crystal defects**

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

Luminescence in solids: Thermoluminescence – Electroluminescence. [13 hrs]

**Unit II Thin films**

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

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

A brief review on mechanical properties of Thin Films.

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

A brief introduction on electron transport phenomena in thin Films. A brief introduction on optical properties of thin films. Reflectance and transmittance of light by thin films. Single layer antireflection coating.

Applications of thin films for: optical components. optical recording, Integrated electronic and optical devices, Band-Gap Engineering and Quantum Devices, Magnetic Recording, 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.

Single particle and Cooper-pair -Josephson tunnelling. AC and DC Josephson effects, Macroscopic Quantum Interference, Superconducting Quantum Interference Devices (SQUIDS). DC and AC SQUIDS. Applications of SQUIDS.

High  $T_C$  superconductors: Discovery YBCO, Important families of high temperature superconductors. [13 hrs]

#### Unit IV Materials II : Polymers & liquid crystals

Polymers : Introduction. Classification. Molecular weight. Configuration. Polymerisation reactions. Polymer processing. Crystallinity. Conducting polymers. Applications.

Liquid crystals : Classification. Structure and texture. Orientational and translational order. Mechanical, optical, magnetic and electrical properties. Liquid crystal displays. [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. Gowariker 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.)

### 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 Digital Signal Processing

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 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).

**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 breeder reactor. [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

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. Rho, Omega and Eta mesons. [13 hrs]

**Unit IV Strange particles and weak interactions**

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

The Quark model – quark composition of particles.

Weak interactions: neutral Kaons. The  $K^0$  -  $\bar{K}^0$  systems. Regeneration of the short lived component of neutral Kaons. CP violation – the CPT theorem

Verification of electromagnetic and weak interactions – intermediate vector bosons. [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)



