St Aloysius College (Autonomous) Mangalore

Re-accredited by NAAC "A" Grade

Course structure and Syllabus

of

M.Sc. PHYSICS

CHOICE BASED CREDIT SYSTEM (CBCS)

(2019 –20 BATCH ONWARDS)

ಸಂತಅಲೋಶಿಯಸ್ ಕಾಲೇಜು (ಸ್ವಾಯತ್ತ)
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Re-accredited by NAAC with 'A' Grade with CGPA 3.62/4
Recognised by UGC as "College with Potential for Excellence"
Conferred "College with "STAR STATUS" by DBT, Government of India.
Centre for Research Capacity Building under UGC-STRIDE

Date: 12-08-2021

NOTIFICATION

Sub: Syllabus of **M.Sc. Physics** under Choice Based Credit System.

Ref: 1. Decision of the Academic Council meeting held on 19-06-2021 vide

Agenda No: 16 (2021-22)

2. Office Notification dated 12-08-2021

Pursuant to the above, the Syllabus of **M.Sc. Physics** under Choice Based Credit System which was approved by the Academic Council at its meeting held on 19-06-2021 is hereby notified for implementation with effect from the academic year **2021-22**.

PRINCIPAL

ST. ALOYSIUS COLLEGE MANGALURU 575 003 (AUTONOMOUS)

REGISTRAR

To:

1. The Chairman/Dean/HOD.
2. The Registrar Office
3. Library
4. PG Office

M.Sc. Physics

Preamble

Physics is the study of nature through theoretical models and experimental means. There are research and educational institutions, both in public and private sectors, which aim to meet these requirements. The main objective of our postgraduate programme in Physics is to imbibe and impart scientific knowledge, which will help the students to enter the field of scientific research, teaching and industry.

A rigorous training through classroom lectures, tutorials and practical training through laboratory modules will be given for the all round development of the students. Innovative methods like student seminars, projects, student faculty programme are introduced to develop the skills of students, which will be useful for teaching and research. Apart from the curriculum, students are trained to enhance the vocational skills and leadership qualities to forge them into good human beings.

The two year M. Sc. Physics programme in the college offers 15 theory courses in Physics, two open electives, seven laboratory courses and a project over a period of four semesters.

Programme Pattern Highlights

The M. Sc (Physics) Programme shall comprise "Core" and "Open Elective" courses. The "Core" courses shall further consists of "Hard core" and "Soft core" courses. Hard core courses shall have 4 credits; soft core courses shall have 3 credits. A candidate has to choose between the two options (A) or (B) for soft core courses. Open electives shall have 3 credits. Total credit for the programme shall be 92 including open electives.

Core courses are related to the discipline of the M. Sc (Physics) programme. Hard core courses are compulsorily studied by a student as a core requirement to complete the programme of M. Sc (Physics). Soft core courses are electives but are related to the discipline of the programme. Two open elective courses 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.

Total credit for the M.Sc (Physics) programme is 92. Out of the total 92 credits of the programme, the hard core (HC) shall make up 56.52 % of the total credits; soft core (SC) is 36.96 % while the open electives (OE) will have a fixed 6 credits (3 credits - 2 papers).

Theory courses

Topics in each theory course are equally distributed in four units for Hard core courses and three units for soft core courses as well as for open electives. Solving and practising certain typical problems shall be exercised in the classrooms.

Lab Courses

1. **General Physics:** A course of general physics experiments are prescribed for all semesters. A rigorous study of theory of the concerned experiment is made along with the development of experimental skills.

2. **Electronics:** First two semesters consist of a course of electronics experiments, one in each semester. The design of electronic circuits is a part of the experiments.

3. **Computational Physics:** One course of Computational Physics has been introduced for the third semester. This will help to solve typical problems in physics by simulation.

Project

There shall be a project in the fourth semester. Evaluation of the project is done by two examiners (one external and one internal). The project will be evaluated for 100 marks out of which 70 marks is assigned for report/dissertation and the remaining 30 marks for internal assessment.

Seminars

A module of seminars has been included in the curriculum to improve presentation skills of the students. Each student has to give a set of two seminars in a semester. The topics for the seminars will be assigned and will be guided by one of the staff. Basic topics from physics will be selected and students will be trained to give seminars on board as well as using power point presentations. The seminar component will fetch 25 marks in each semester.

Course Details

Semester I					
Code	Title	Lecture/Lab	Tutorial	Nature	Credits
PH 571.1	Mathematical Physics I	4	1	HC	4
PH 572.1	Classical Mechanics	4	1	HC	4
PH 573.1	Classical Electrodynamics	4	1	HC	4
PH 574.1	Electronics	4	1	HC	4
PS 575.1P	General Physics Experiments - I	6 (Lab)		SC	3
PS 576.1P	Electronics Experiments - I	6 (Lab)		SC	3
	Seminar	2		SC	1
Semester II					
PH 571.2	Mathematical Physics II	4	1	HC	4
PH 572.2	Quantum Mechanics I	4	1	HC	4
PH 573.2	Thermodynamics and Statistical Physics	4	1	HC	4
PH 574.2	Condensed Matter Physics I	4	1	HC	4
PS 575.2P	General Physics Experiments - II	6 (Lab)		SC	3
PS 576.2P	Electronics Experiments - II	6 (Lab)		SC	3
PO 577.2	**Bio Physics**	3	1	OE	3
	Seminar	2		SC	1
Semester III					
PH 571.3	Quantum Mechanics II	4	1	HC	4
PH 572.3	Condensed Matter Physics II	4	1	HC	4
PS 573.3	Relativity and Cosmology	3	1	SC	3
PS 574.3	Optics	3	1	SC	3
PS 575.3P	General Physics Experiments - III	6 (Lab)		SC	3
PS 576.3P	Computational Physics Practicals	6 (Lab)		SC	3
PO 577.3	**Experimental Techniques**	3	1	OE	3
	Seminar	2		SC	1
Semester IV					
PH 571.4	Atomic and Molecular Physics	4	1	HC	4
PH 572.4	Nuclear and Particle Physics	4	1	HC	4
PH 573.4P	Project	8 (Lab)		HC	4
PS 574.4	Communication Theory	3	1	SC	3
PS 575.4	Lasers, Vacuum Techniques and Nonlinear Optics	3	1	SC	3
PS 576.4	Condensed Matter Physics III	3	1	SC	3
PS 577.4	Nuclear Structure	3	1	SC	3
PS 578.4P	General Physics Experiments IV	6 (Lab)		SC	3
	Seminar	2		SC	1

Theory Question Papers

Hard Core

- Each question paper has two parts – Part A and Part B.
- Part A of a hard core paper contains 8 questions with internal choice, selecting 1 question from each unit carrying 15 marks each.
- Part B of hard core paper contains 4 questions out of which the candidate has to answer 2 questions of 5 marks each.

The question paper pattern is as follows:

St Aloysius College (Autonomous), Mangaluru
End Semester Examination - M. Sc. Physics
Hard core paper

Time: 3 hours Max marks: 70

Part A

Answer all questions choosing one from each unit. [15× 4=60]

Unit I

1. a
   b [15 marks]

OR

2. a
   b [15 marks]

Unit II

3. a
   b [15 marks]

OR

4. a
   b [15 marks]

Unit III

5. a
   b [15 marks]

OR

6. a
   b [15 marks]

Unit IV

7. a
   b [15 marks]

OR

8. a
   b [15 marks]

Part B

9. Answer any **two** questions [5×2=10]
   a
   b
   c
   d

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Soft core/Open elective

- Each question paper consists of two parts A and B.
- Part A of a soft core/open elective paper contains 6 questions with internal choice, selecting 1 question from each unit carrying 18 marks each.
- Part B of soft core/open elective paper contains 6 questions out of which the candidate has to answer 4 questions of 4 marks each.

St Aloysius College (Autonomous), Mangaluru
End Semester Examination - M. Sc. Physics
Soft core/Open Elective

Time: 3 hours Max marks: 70

Part A

Answer all questions choosing one from each unit. [18× 3=54]

Unit I

1. a
   b [18 marks]

OR

2. a
   b [18 marks]

Unit II

3. a
   b [18 marks]

OR

4. a
   b [18 marks]

Unit III

5. a
   b [18 marks]

OR

6. a
   b [18 marks]

Part B

7. Answer any **four** questions [4×4=16]
   a
   b
   c
   d
   e
   f

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Internal Assessment

1	Two internal tests	25
2	Surprise tests, Quiz etc.	12
3	Assignment, report writing	10
4	Class participation	03
	Total	**50***

*From the above, the internal marks are converted into 30.

Practicals

1. One experiment of 4 hour duration will be conducted, with maximum 100 marks for each practical paper. Marks obtained by a candidate out of 100 are given a weightage of 0.7 so that the candidate is assessed out of 70 marks per paper.
2. Maximum marks for internal assessment is 30 per paper, which is awarded conducting an internal practical examination.

Theory courses

Semester I

PH 571.1 Mathematical Physics - I

Unit I Vector analysis and curvilinear coordinates [13 hours]

Integration of vector function - line integral, surface integral and volume integrals - vector theorems Gauss, Green's theorem and Stoke's theorem (without proof) and their applications in Physics.

Rotation of coordinates, Orthogonal curvilinear coordinates, Gradient, Divergence and Curl in orthogonal curvilinear coordinates, Rectangular, cylindrical and spherical polar coordinates.

Unit II Matrices and Tensors [13 hours]

Matrices: Review of Basic properties of matrices, Orthogonal matrices, Hermitian and Unitary matrices, Similarity and Unitary transformations, Diagonalization of matrices, Cayley - Hamilton Theorem. Eigen values and eigenvectors.

Tensors: Introduction - rank of a tensor. Transformation of coordinates in linear spaces - transformation law for the components of a second rank tensor. Contravariant, covariant and mixed tensors - First rank tensor, higher rank tensors, symmetric and antisymmetric tensors. Tensor algebra - outer product - contraction - inner product - quotient law.

Unit III Partial Differential equations [13 hours]

First order partial differential equations for a function of two variables. Linear second order partial differential equations - classification into elliptic, parabolic and hyperbolic types. Laplace, wave and heat equations in two and three dimensions (Cartesian, cylindrical and spherical polar coordinates). Separation of variables and Singular points.

Unit IV Special functions [13 hours]

Review of power series method for ordinary differential equations - description of beta and gamma functions.

Bessel's functions: solution of Bessel's equation-Neuman and Hankel functions - generating function and recursive relations, orthogonality of Bessel's functions - Spherical Bessel's functions.

Legendre polynomials: solution of Legendre equation - Neumann and Hankel functions, Generating function and Recurrence relation, Orthogonality property of Legendre polynomials, Associated Legendre polynomials, Associated legendre Polynomials and spherical harmonics.

Laguerre Polynomials: Solution of Laguerre equation, Laguerre and associated Laguerre polynomials.
Hermite polynomials - solution of Hermite equations, generating functions and recurrence relations.

Reference books:

1. Arfken G B, Weber H J, Harris F E, 'Mathematical Methods for Physicists', (VII Edn. Academic Press, 2013)
2. Harper C, 'Introduction to Mathematical Physics', (PHI, 1976)
3. Mary L Boas, 'Mathematical Methods in the Physical sciences', (John Wiley, 1983)
4. Kreyszig E, 'Advanced Engineering Mathematics', (X Edn. Wiley Eastern, 2011)
5. Spigel M R, 'Vector Analysis - Schaum series', (II Edn. McGraw Hill. 2009)
6. Joshi A W, 'Matrices and Tensors in Physics', (Wiley Eastern, 1995)
7. Ghatak A K , Goyal I C, Chua S J,'Mathematical Physics, Differential Equations and Transform Theory', (MacMilan Publisher India Ltd, 1985)
8. Chattopadyaya P K, 'Mathematical Physics', (Wiley Eastern, 1990)

PH 572.1 Classical Mechanics

Unit I: System of particles and Lagrangian formalism [13 hours]
Mechanics of a system of particles. Conservation of linear momentum, energy and angular momentum. Constraints. Degrees of freedom, generalised coordinates. D'Alembert's Principle, Lagrange's equations of motion. Simple applications of Lagrangian formalism. Calculus of variation, Variational principle, Euler - Lagrange equations. Advantages of variational method. Phase space, Phase trajectories. Applications to systems with one and two degrees of freedom.

Unit II: Hamiltonian formalism and Canonical transformations [13 hours]
Generalized momenta, Hamiltonian function, Physical significance and the Hamilton's equations of motion: The Hamiltonian of a particle in a central force field. Principle of least action: derivation of equation of motion, variation and end points.
Canonical transformations, Generating functions, Examples of canonical transformations, Infinitesimal canonical transformations. Poisson brackets. Hamilton Jacobi theory, the simple harmonic oscillator as an example. Action-angle variables.

Unit III: Central Force problem [13 hours]
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, Virial theorem, 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.

Unit IV: Rigid body dynamics [13 hours]
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.

Reference Books:

1. Goldstein H, Poole P.C, Safko J 'Classical mechanics', (III Edn, Pearson 2011)
2. Landau L D, Lifshitz E M, 'Mechanics - A course on theoretical Physics - Volume I', (Elsevier, 2007)
3. Calkin M G, 'Lagrangian and Hamiltonian dynamics', (World scientific, 1998)
4. Percival I., Richards D., 'Introduction to Dynamics', (Cambridge University Press, 1987)
5. Takwale R G, Puranik P S, 'Introduction to Classical Mechanics', (Tata McGraw Hill, 1979)
6. Greiner W, 'Classical Mechanics: Systems of Particles and Hamiltonian Dynamics', (Springer, 2004)
7. Rana N C, Joag P S, 'Classical Mechanics', (Tata McGraw Hill, 2011)
8. Upadhyaya J C, 'Classical Mechanics', (Himalaya Publishing House, 2012)

PH 573.1 Classical Electrodynamics

Unit I Electrostatics and magnetostatics [13 hours]
Electrostatics - Review of scalar and vector fields. Poisson's and Laplace's equations. Laplace's equation in one, two and three dimensional problems (Cartesian co - ordinates). Boundary conditions and uniqueness theorem. Method of images and applications. Multipole expansion. Electric dipole field, Field inside a dielectric.
Magnetostatics - vector potential. Boundary conditions. Multipole expansion of vector potential. Magnetisation. Magnetic field inside matter.

Unit II Electromagnetic theory [13 hours]
Maxwell's equations. Scalar and vector potentials. Gauge transformations. Coulomb gauge and Lorentz gauge. Energy and momentum in electrodynamics. Poynting theorem. Retarded potentials. Electric and magnetic dipole radiation. Liénard - Wiechert potentials. Fields of a point charge in motion, slowly moving. Power radiated by a point charge oscillation.

Unit III Electromagnetic waves [13 hours]
Propagation of plane waves in free space, dielectrics and conducting media. Reflection and refraction of electromagnetic waves.
Wave Guides: Modes in rectangular and cylindrical wave guides. Resonant cavities. Evanescent waves. Energy dissipation. Q of a cavity.

Unit IV Electrodynamics and Relativity [13 hours]
Special Relativity: Principle and postulate of relativity. Lorentz transformations. Length contraction, time dilation and the Doppler effect. Velocity addition formula. Four - vector notation.
Relativistic electrodynamics: Magnetism as a relativistic phenomenon, Transformation of the field, Electric field of a uniformly moving point charge, Electromagnetic field tensor, Electrodynamics in tensor notation, Potential formulation of relativistic electrodynamics. Maxwell's Equatins in Four Vector Notations

Reference Books:

1. Griffiths D J, 'Introduction to Electrodynamics', (III Edn. PHI, 2009)

2. Jackson J D, 'Classical Electrodynamics', (III Edn. John Wiley,1999)

3. Reitz J R, Milord F J, Christy R W, 'Foundations of Electromagnetic

Theory', (III Edn. Narosa Publishing House, 1990)

4. Lorrain P and Corson D, 'Electromagnetic fields and waves', (CBS Publishers and Distributers, 1986)
5. Panofsky W K H, Phillips M, 'Classical electricity and Magnetism', (II Edn., Dover, 2005)
6. Chirgwin B H, Plumpten C, Kilmister C W, 'Elementary Electromagnetic Theory', Vols.1,2 and 3', (Pergamon Press, 1972)
7. Resnick R, 'Introduction to Special Relativity', (Wiley 2007)
8. Rindler D., 'Special Theory of Relativity', (Oxford University Press, 1982)

PH 574.1 Electronics

Unit I Operational amplifiers [13 hours]
Opamp with negative feedback. Voltage/current feedback amplifiers. Practical opamps-output offset voltage, frequency response. Applications: summing, scaling and averaging amplifiers, instrumentation amplifiers, integrator, differentiator, active filters, comparators, Schmitt trigger.

Unit II Waveform generators and Specialized IC applications [13 hours]
Sine wave , square wave, triangular wave, saw tooth wave generators, voltage controlled oscillators, unijunction oscillators.
555 - timer - monostable and astable multivibrators - applications. Phase locked loop - phase detector. Low pass filter. Voltage controlled oscillator, frequency multipliers.

Unit III Power Amplifiers, Devices and transducers [13 hours]
Class A, B and AB amplifiers, amplifier distortion, heat sinking.
SCR- characteristics and applications. Solar cells, IR emitters. Transducers - temperature, pressure, vacuum, magnetic fields, vibration, optical and particle detectors. Signal conditioning, and shielding, Shielding and grounding, Lock in detector, Boxcar integrator, High frequency devices (generators and detectors).

Unit IV Digital electronics [13 hours]
The Karnaugh map - Boolean expression simplification, decoders, encoders, MUX and DeMUX.Introduction to flip-flops - RS, JK, Master and slave. Counters - synchronous and asynchronous. Shift registers, semiconductor memory RAM, ROM,PROM, EPROM, EEPROM, flash memory, CCD memory, Comparators, A/D, D/A, Microprocessor and Microcontroller basics.

Reference books:

1. Boylestad R L and Nashelsky L, 'Electronic Devices & Circuit Theory', (X Edn. Pearson Education India, 2009)

2. Coughlin R F and Driscoll F F, 'Operational Amplifiers and Linear integrated circuits', (VI Edn. Prentice Hall of India, 2009)

3. Gayakwad R .A, 'Opamps and Linear Integrated Circuits', (Prentice Hall of India,2002)

4. Patranabis D, ‘Sensors and Transducers’, (Prentice Hall of India, 2004)
5. Murthy D. V. S, ‘Transducers and Instrumentation’, (Prentice Hall of India, 2004)
6. Rangan C S, Sarma G R, Mani V S V, ‘Instrumentation: Devices and Systems’, (Tata McGraw Hill, 1983)
7. Tocci R. J, Widemer N.S, Moss G. L , ‘Digital systems: Principles and Applications’, (Prentice Hall of India, 2009)
8. Tokheim R. L, ‘Digital Electronics: Principle and Applications’, (McGraw Hill, 2007)
9. Floyd T L, ‘Digital Fundamentals’, (Pearson Education India, 2006)
10. Morris Mano M, ‘Digital logic and computer Design’, (Pearson Education India, 2008)
11. Rajaraman V, Radhakrishnan T, ‘An Introduction to Digital Computer Design’, (PHI, 2004)

PS 575.1P General Physics Experiments - I

1. Quarter Wave Plate
2. Modes of Vibration
3. Young's Modulus by Koenig's Method
4. Mass attenuation Coefficient using G M counter
5. $\frac{e}{k}$ using Transistor
6. Study of LDR and LED using Constant Deviation Spectrometer
7. Diffraction at a Straight Edge
8. Specific Charge of electron - Thomson's method
9. Dielectric constant and curie temperature
10. Wavelength of laser using reflection grating
11. Diffusivity of Brass
12. Random nature of Radio Activity

(Additional experiments may be added)

PS 576.1P Electronics Experiments - I

1. Monostable and Astable Multivibrator using IC 555
2. First order low pass and high pass butter worth filters
3. OPAMP based Schmitt trigger
4. Astable Multivibrator using transistor
5. FET characteristics
6. Transistor biasing
7. Logic Gates
8. Amplifiers using OPAMP
9. Clippers and Clampers
10. C E amplifier

Additional experiments may be added

Semester II

PH 571.2 Mathematical Physics - II

Unit I Complex variables [13 hours]
Complex variables - Review of functions of complex variables - Cauchy Reimann conditions, contour integrals, Cauchy integral theorem, Cauchy integral formula. Taylors and Laurent's series. Zero isolated singular points, simple poles, mth 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. Dispersion relations. Geometrical representation - conformal mapping. Dirac delta function and its properties.

Unit II Group Theory and Green's function [13 hours]
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. Construction of representations. Representation of groups and quantum mechanics. Lie groups and Lie algebra. Three dimensional rotation group SO(3), SU(2) and SU(3) groups.
Introduction to Green's function, properties of Greens function, Greens function for ∇^2 operator, solution for Poisson equation using Green's function techniques.

Unit III Integral Transforms [13 hours]
Fourier integral and Fourier transform - Definition - special form of Fourier integral and properties. Convolution theorem involving Fourier transform. Applications of Fourier transform. Laplace's transforms. Convolution theorem involving Laplace's transforms. Application of Laplace's transforms.

Unit IV Numerical methods [13 hours]
Solution of a system of linear simultaneous equations. Gauss Jordan method, Gauss - Seidel iterative method.
Interpolation - Definition of interpolating polynomial - finite difference operators - Newton's forward and backward interpolation formulas - examples. Finite difference expression of order one and two for y' and y" . Numerical integration - integration by trapezoid and Simpson's rule, Solution of ordinary differential equations of first order, Runge Kutta method of order 4.

Reference books:

1. Arfken G B, Weber H J, Harris F E, 'Mathematical Methods for Physi-

cists', (VII Edn. Academic Press, 2013)

2. Harper C, 'Introduction to Mathematical Physics', (PHI, 1978)
3. Mary L Boas, 'Mathematical Methods in the Physical Sciences', (John Wiley, 1983)
4. Kreyszig E, 'Advanced Engineering Mathematics', (X Edn. Wiley Eastern, 2011)
5. Brown J W, Churchill R V, 'Complex Variables and Applications', (V Edn. McGraw Hill, 2004)
6. Joshi A W, 'Elements of Group Theory for Physicists', (New Age International, 1997)
7. Sastry S. S, 'Introductory methods of Numerical Analysis', (PHI Learning Pvt Limited, 2005)

PH 572.2 Quantum Mechanics - I

Unit I General formulation of quantum mechanics [13 hours]
Review of concepts of wave particle duality, matter waves, wave packet and uncertainty principle, Schrödinger equation for free particle in 1 and 3 dimensions – equation subject to forces. Probability interpretation of wave function, probability current density – normalization of wave function, box normalization, expectation values and Ehrenfest's theorem.

Unit II Fundamental postulates of quantum mechanics 13 hours]
Postulates of quantum mechanics, Representation of states, dynamical variable, adjoint of an operator. Eigen value problem, degeneracy, eigen values and eigen functions. The dirac delta function, completeness and normalization of eigen functions, closure, physical interpretation of eigen values, eigen functions and expansion coefficients, eigen functions and eigen values using commutation relations, momentum eigen functions.

Unit III Stationary states and eigen value problem [13 hours]
Time independent Schrodinger equation, particle in square well – bound state - normalized state. Potential step and rectangular potential barrier, reflection and transmission coefficients – tunneling of particles. Harmonic oscillator, energy eigen values, energy eigen functions. Properties of stationary states.

Unit IV Angular momentum, parity and scattering [13 hours]
Angular momentum operators, eigen value equation for L^2 and L_z – separation of variables. Admissibility condition 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, Born approximation (qualitative).

Reference books:

1. Mathews P. M., Venkatesan K., 'A text book of Quantum Mechanics', (Tata McGraw Hill)

2. Schiff L I, 'Quantum Mechanics' (III Edn. McGraw Hill 1968)

3. Griffiths D J, 'Introduction to Quantum Mechanics', (II Edn. Pearson,

2011)

4. Cohen Tannoudji C, Diu B, Laloë F, 'Quantum Mechanics (2 volumes)', (Wiley, 1992)

5. Sakurai J J, 'Modern Quantum Mechanics', (II Edn. Pearson, 2011)

6. Ghatak A K, Lokanathan S, 'Quantum Mechanics: Theory and Application', (III Edn. Mc Millan India, 1994)

7. Powell J L, Crasemann B, 'Quantum Mechanics', (Addison Wesley, 1961)

8. Jain M. C., 'Quantum Mechanics, A Textbook for Undergraduates', (III Edn. PHI, 2012)

9. Arul Das G, 'Quantum Mechanics', (PHI, 2009)

PH 573.2 Thermodynamics and Statistical Physics

Unit I Thermodynamics [13 hours]
Concept of entropy - principle of entropy increase - entropy and disorder. Enthalpy - Helmoltz and Gibb's functions. Maxwell's relations - TdS equations - energy equations - Heat capacity equations - heat capacity at constant pressure and volume. Application to specific heats. Phase space and ensembles - Microcanonical ensemble, Canonical ensemble, Liouville's theorem, probability - thermal equilibrium.

Unit II Classical statistics [13 hours]
Maxwell - Boltzmann distribution - partition functions - translational partition function. Gibbs' paradox, Sackur - Tetrode equation - vibrational, rotational and electronic partition functions. Boltzmann equipartition theorems.

Unit III Quantum statistics [13 hours)]
Density operator, Statistics of ensembles - micro,canonical and grand canonical ensembles, Bose - Einstein and Fermi - Dirac distributions, Behaviour of ideal Bose gas - Bose Einstein condensation - Planck's law of black body radiation, Ideal Fermi system - Fermi temperature - Fermi energy - electron gas in metals.

Unit IV Random motion and fluctuations [13 hours]
Brownian motion - Langevin theory - Einstein relations, Approach to equilibrium - Fokker Planck equation, Fluctuations - fluctuation dissipation theorem - power spectrum of fluctuations - persistence and correlation of fluctuation - Wiener-Khinchin theorem, Nyquist theorem.

Reference Books:

1. Zemansky M W, Dittman R H, 'Heat and Thermodynamics', (VIII Edn. McGraw Hill International Edn. 2011)

2. Reif F, 'Fundamentals of Statistical and Thermal Physics', (Levant Books 2010)

3. Pathria R K, 'Statistical Mechanics', (III Edn. Elsevier 2011)

4. Kerson Huang, 'Statistical Mechanics', (II Edn. Willey India, 2010)

5. Daniel V Schroeder, 'An Introduction to Thermal Physics', (Pearson, 2008)

6. Landau L D, Lifshitz E M, 'Statistical Physics', (III Edn. Oxford, 1980)

PH 574.2 Condensed Matter Physics - I

Unit I Crystallography [13 hours]
Bravais lattice. Primitive vectors. Unit cell. Primitive and conventional unit cell. Wigner - Seitz cell. Reciprocal lattice - SC, FCC, BCC. First Brillouin zone. Lattice directions, planes. Miller indices.
X-ray production and spectra. X-ray filters. X-ray diffraction. Formulation of Bragg and Von Laue condition. Ewalds construction. Experimental methods - Laue and Powder. Geometric structure factor. Atomic form factor. Symmetry operations. Crystal systems. Crystallographic point groups and space groups. Quasi - crystals.

Unit II Crystal binding and Thermal properties of insulators [13 hours]
Bond length, bond angle, bond energy. Primary and secondary bonds. Coordination numbers. Ionic, covalent, molecular, hydrogen bonded crystals. Cohesive energy - Madelung constant.
Normal modes of monoatomic and diatomic lattice vibrations. Phonon momentum. Inelastic scattering of photons and neutrons by phonons.
Thermal expansion. Lattice thermal conductivity - Umklapp andnormal processes.

Unit III Free electron model of metals [13 hours]
Electrical and thermal conductivity. Hall effect. Magnetoresistance. Thermoelectric power. Born von Karman boundary condition. Density of states. Fermi energy, F.D. distribution. Electronic specific heat. Sommerfeld theory of electric conductivity. Inadequacies of free electron theory.
Electrons in periodic potential
Bloch theorem. Kronig - Penney model. Brillouin zones. crystal momentum. Effective mass tensor. Concept of holes. Constant energy surface. Metals, semimetals, insulators and semiconductors.

Unit IV Semiconductors [13 hours]
Intrinsic semiconductors: Band structure. Direct and indirect gap semiconductors. Effective mass. Carrier concentration.
Extrinsic semiconductors: Ionization energy of impurity atoms. Population of impurity levels. Fermi energy. Electrical conductivity. Cyclotron resonance. Quantised Hall effect. Degenerate, amorphous and organic semiconductors.

Reference books:

1. Verma A R, Srivastava O N, 'Crystallography Applied to Solid State Physics', (II Edn. New Age International, 2008)
2. Kittel C, 'Introduction to Solid State Physics', (VIII Edn. Wiley India, 2005)
3. Ashcroft N W, Mermin N D, 'Solid State Physics', (Harcourt Asia, 1974)
4. Ibach H, Luth H, 'Solid State Physics', (Narosa, 1991)
5. Omar A , 'Elementary Solid State Physics', (Pearson India, 1999)
6. Cullity B D, Stock S R, 'Elements of X-ray Diffraction', (Prentice Hall, 2001)
7. Podesta M D, 'Understanding The Properties Of Matter', (II Edn. Taylor - Francis, 2002)
8. Blakemore J S, 'Solid State Physics', (II Edn. Cambridge University Press, 1985)
9. McKelvey J P, 'Solid State Physics for Engineering and Materials Science', (Kreiger, 1992)
10. McKelvey J P, 'Solid State And Semiconductor Physics', (Kreiger, 1982)
11. Sze S M, Ng K K, 'Physics Of Semiconductor Devices', (Wiley India, 2012)
12. Jasprit Singh, 'Semiconductor Devices: Basic Principles', (John Wiley, 2007)

PS 575.2P General Physics Experiments - II

1. Michelson's Interferometer
2. Diffraction at a single slit
3. Verification of Malu's Law
4. Energy gap of a Semiconductor
5. Determinations of Cauchy's constants
6. Rydberg's Constant using Hydrogen Spectrum
7. Determination of resolving time of a G M counter (two source method)
8. Determination of Brewster's Angle
9. Young's Modulus using cantilever vibration
10. Charecteristics of Photodiode using Constant deviation spectrometer
11. Fresnel's law of Reflection
12. Thermocouple

Additional experiments may be added

PS 576.2P Electronics Experiments - II

1. Mono-stable Multivibrator (Transistor)
2. Bi-stable Multivibrator (Transistor)
3. Two stage CE Amplifier
4. Amplitude Modulation and Demodulation
5. Frequency Modulation and Demodulation
6. Voltage Controlled Oscillator
7. Phase-shift & Wein-bridge Oscillators (Transistor)
8. Voltage regulators
9. Decoders and Encoders

10. Multiplexers and Demultiplexers
11. Phase Locked Loop - IC 565
12. Counters

Additional experiments may be added

PO 577.2 Biophysics

Unit I Interaction of radiation with matter, Radiation Detectors [13 hours]
Radioactivity. radiation dosimetry, interaction of heavy charged particles, electrons, EM radiations, neutrons, cross-sections. Gas filled counters-GM counter, scintillation detectors- NaI (Tl) , semiconductor detectors (Ge/Si), neutron detectors, energy measurements.

Unit II Effects of radiation on DNA and cells [13 hours]
Radiation effects on DNA- Strand breaks, base damage, cross links. Repair of damaged DNA- repair of base damage, repair of strand breaks, Dsb repair. Numerical aberrations, Structural aberrations, Chromosome type aberrations, Chromatid aberrations, Radiation dose response of chromosomal aberrations, Kinetics of break joining, Gene mutations.

Unit III Molecular Biophysics [13 hours]
Introduction, Biological applications of delocalization of molecules.
Nucleic acids: DNA and RNA, Radiation damage in Nucleic acids. Proteins: Haemoglobin and Myoglobin molecules, Enzyme studies, Photosynthesis and Carcinogenic activities.

Reference books:

1. Knoll G F, “Radiation Detection and Measurement”, (II Edn. John Wiley, 1989)

2. Kapoor S S, Ramamurthy V S, “Nuclear Radiation Detectors”, (New Age International, 1986)

3. Coterill R M J, “Biophysics: An Introduction”, Wiley India, (2002)

4. Uma Devi P, Satish Rao B S, Nagarathnam A, “Introduction to Radiation Biology”, B.I. Churchill Livingstone Pvt. Ltd, New Delhi (India), (2000)

5. Omar M A, “Elementary Solid State Physics: Principles and Applications”, Addison Wesley Pub. Co.

Semester III

PH 571.3 Quantum Mechanics - II

Unit I Matrix formalism of quantum mechanics [13 hours]
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 inequality theorem - proof of Heisenberg uncertainty relation.

Unit II Quantum dynamics [13 hours]
Equations of motion - Schrodinger and Heisenberg picture - quantum Poisson bracket. Interaction picture. Harmonic oscillator problem solved by matrix method.
Angular momentum - angular momentum operator, commutation relations - raising and lowering operators - eigen values and eigen functions of J^2 and J_z - addition of two angular momentum - Clebsch-Gordan coefficients - the 3 - j symbol - Pauli spin matrices.

Unit III Approximation methods [13 hours]
Perturbation theory for discrete levels - equations in various orders of perturbation theory - non-degenerate and degenerate cases, simple examples. Time dependent perturbation theory.
The Variational Method - the hydrogen molecule - exchange interaction. The WKB method.

Unit IV Relativistic quantum mechanics and elements of field quantization [13 hours]
Klein-Gordan equation for a free particle - Dirac equation - Dirac matrices - Dirac equation for central fields - negative energy solution, spin and magnetic moment of the electron.
Transition from particle to field theory. Second quantisation of the Schrödinger equation. Creation and annihilation operators - commutation and anti - commutation relation and their physical implications.

Reference Books:

1. Thankappan V K, 'Quantum Mechanics', (Wiley Eastern Ltd., 1993)

2. Merzbacher E, 'Quantum Mechanics', (III Edn. John Wiley & Sons, 1998)

3. Shankar R, ‘Principles of Quantum Mechanics’, (Springer, 2013)
4. Griffiths D J, ‘Introduction to Quantum Mechanics’, (II Edn. Pearson 2011)
5. Zettili N, ‘Quantum mechanics Concepts and Applications’, (II Edn. Wiley 2010)
6. Sakurai J J, ‘Modern Quantum Mechanics’, (II Edn. Pearson, 2011)
7. Schiff L I , ‘Quantum Mechanics’, (III Edn. McGraw Hill, 1969)
8. Greiner W, ‘Relativistic Quantum Mechanics: Wave Equations’, (III Edn. Springer, 2000)

PH 572.3 Condensed Matter Physics II

Unit I Crystal Imperfections and Phase Transitions In Solids [13 hours]
Point defects. Energy of formation. Diffusion. Electrical conductivity of ionic crystals. Color centres. Polarons. Excitons.
Line defects: Dislocations, Burger's vector. Effect on crystal growth. Crystal strength. Whiskers. Observation of dislocations.
Surface imperfections. Stacking fault.
Luminescence in solids: Fluorescence and phosphorescence. Sulphide and KCl phosphors. Thermoluminescence.
Phase Transitions In Solids: Thermodynamic classification and relations at phase transitions. Order – disorder transitions. Landau theory. Transitions in ferroelectric crystals and Liquid crystals.

Unit II Magnetism [13 hours]
Dia and paramagnetism: Atoms with completely and partially filled shells. R - S coupling. Hund's rules.
Brillouin- Langevin theory of paramagnetism. Rare earth and iron group ions. Pauli paramagnetism.
Magnetic order
Ferromagnetism: Exchange interaction. Heisenberg Hamiltonian. Mean field theory. Spin waves. Dispersion relation for magnons. Bloch $T^{\frac{3}{2}}$ law. Magnetocrystalline anisotropy. Ferromagnetic domains. Hysteresis. Hard and soft magnets. Applications. Neutron diffraction.
Antiferromagnetism: Molecular field theory.
Ferrimagnetism: Mean field theory. Spinels and garnets.

Unit III Magnetic resonance [13 hours]
Electron spin resonance: Resonance condition, spin lattice relaxation, Line width, Absorption of microwave energy, Crystal field splitting.
Nuclear magnetic resonance: Resonance condition, Spin lattice and spin spin relaxation. Proton NMR spectroscopy. Continuous and FT NMR. NMR spectrometer. Pulse echo method. Knight shift. Line width. Motional narrowing. Chemical shift. Magnetic resonance imaging. Quadrupole effects and resonance. Ferromagnetic resonance.

Unit IV Dielectric Properties of Solids [13 hours]
Polarization. Dielectric susceptibility. Dielectric constant. Dielectric loss and loss angle.
Local electric field. Polarizability. Claussius - Mossotti relation. Electronic, ionic, dipole polarizability. Dielectric strength.

Freqency dependent dielectric function. Optical properties of ionc crystals. LST equation. Dipole orientation in solids. Langevin function. Dipole relaxation.
Elastic properties of solids: Analysis of elastic stress and strain. Elastic compliance and stiffness constants. Energy density of cubic crystals and isotropic solids. Elastic waves in cubic crystals. Experimental determination of elastic constants.

Reference books:

1. Kittel C, 'Introduction to Solid State Physics', (VIII Edn. Wiley India, 2005)
2. Ashcroft N W, Mermin N D, 'Solid State Physics', (Harcourt Asia, 1976)
3. Ibach H, Luth H, 'Solid State Physics', (Narosa, 1991)
4. Rao C N R, Rao K J, 'Phase transitions in Solids', (McGraw Hill,1978)
5. Mnyukh Y., 'Fundamentals of Solid State Phase Transitions, Ferromagnetism and Ferroelectricity', (Direct Scientific Press, 2010)
6. Papon P, Leblond J, Meijer P H E, Schnur S L, 'The Physics of Phase Transitions', (Springer, 2006)
7. Stanley H E, 'Introduction to Phase Transition and Critical Phenomena', (Oxford University Press, 1987)
8. Chandrasekhar S, 'Liquid Crystals', (Cambridge University Press, 1992)
9. Coey J M D, 'Magnetism and magnetic materials', (Cambridge, 2010)
10. Jiles D C, 'Introduction to Magnetism and Magnetic Materials', (CRC Press, 1998)
11. Morrish A H, 'Physical Principles of Magnetism', (Wiley, 2001)
12. Keeler J, 'Understanding NMR Spectroscopy', (II Edn. Wiley, 2010)
13. Kaur H, 'Instrumental Methods of Chemical Analysis', (V Edn. Pragathi Prakashan, 2009)
14. Bruesch P, 'Phonons: Volume I, II, III', (Spinger series on Solid State Sciences, 2012)

PS 573.3 Relativity and Cosmology

Unit I Special Relativity and Tensor Calculus [13 hours]
Special Relativity: Four vector formulation. Lorentz transformations, Time dilation, relativistic mechanics, Energy momentum four vector.
Tensor Calculus: Metric tensor, Affine connection, Covariant differentiation, parallel transport, Riemann – Christoffel curvature tensor, Ricci tensor, Geodesics.

Unit II General theory of relativity [13 hours]
Principle of Equivalence, Principle of General Covariance, Derivation of Einstein field equation, Brans – Dicke theory, Energy, Momentum and Angular Momentum of gravitation.
Schwarzchild solutions, General equations of motion, Deflection of light by sun, Precession of perihelia, Schwarzchild singularity.

Unit III Cosmology [13 hours]
The cosmological principle, Robertson – Walker metric, Red shift. Cosmic microwave radiation background, Early universe, Formation of galaxies.
Cosmological models: Olber's paradox, Steady state model, Hubble's law, Expanding Universe, Inflationary model

Reference Books:

1. Resnick R, 'Introduction to Special Relativity', (Wiley India, 2005)
2. Dixon W G, 'Special Relativity: The Foundation of Macroscopic Physics', (Cambridge University Press, 1982)
3. Weinberg S, 'Gravitation and Cosmology: Principles and Applications of The General Theory of Relativity', (Wiley, 2013)
4. Hartle J B, 'Gravity: An Introduction to Einstein's General Relativity', (Pearson, 2003)
5. Schutz B F, 'A First Course in General Relativity', (Cambridge University Press, 1985)
6. Narlikar J V, 'An Introduction to Cosmology', (Cambridge University Press, 2002)
7. Narlikar J V, 'An Introduction to Relativity', (Cambridge University Press, 2010)

8. Weinberg S, 'Cosmology', (Oxford University Press, 2008)

PS 574.3 Optics

Unit I Nature of Light [13 hours]

Waves: Plane progressive wave in 1-D and 3-D. Plane wave and spherical wave solutions.. Dispersion: phase velocity and group velocity. Fermat's principle: Fermat's principle and its application on plane and curved surfaces. Different types of magnification : Helmholtz and Lagrange's equations, paraxial approximation, introduction to matrix methods in paraxial optics – simple application. Wave theory of light: Huygen's principle; deduction of law of reflection and refraction.

Unit II Physical Optics [13 hours]

Interference: Young's experiment; spatial and temporal coherence; intensity distribution; Fresnel's biprism, interference on thin film, Newton's ring. Michelson's interferometer. Multiple beam interference – reflected and transmitted pattern. Fabry-Perot interferometer.

Diffraction of light waves: Fresnel and Fraunhofer class, Fresnel's half period zones; zone plate. Fraunhofer diffraction. Plane diffraction grating (transmission). Rayleigh criterion of resolution; resolving power of prism, telescope, microscope and transmission grating.

Polarisation: Different states of polarisation; double refraction, Huygen's construction for uniaxial crystals; polaroids and their uses. Production and analysis of plane, circularly and elliptically polarised light by retardation plates and rotatory polarisation.

Unit III Applied optics: Electro-optic and Acousto-optic effects [13 hours]

Electro optic effect: Introduction, Electro optic effect in KDP crystals (longitudinal and transverse modes), index ellipsoid in the presence of an external electric field

Acousto-optic effect: Introduction, Raman - Nath diffraction, Experimental set up and theory, Bragg diffraction, Bragg diffraction for small angles and large angles.

References

1. Hecht E, "Optics", Pearson Education, 5th edition (2015)
2. Jenkins F. A., White H. E., "Fundamentals of Optics", Tata Mc-Graw Hill Education (2011)
3. Ghatak A. K., "Optics", IV Ed. Tata Mc-Graw Hill Education (2005)
4. Halliday D., Resnick R., Walker J., "Fundamentals of Physics", IX Ed. John Wiley and & Sons (2011)

5. Ghatak A. K., Thyagarajan K., "Optical Electronics", Cambridge University Press, (1991)

PS 575.3P General Physics Experiments - III

1. Lorentz number of Copper
2. Magnetic susceptibility - Quincke's method
3. Magnetic susceptibility - Gouy's method ($NiSO_4$, $FeSO_4$, $CoSO_4$)
4. Magnetic Field Mapping around a Circular Coil carrying current
5. Babinet's Compensator
6. U V Spectroscopy
7. Hall effect - Determination of Hall Coefficient
8. Diffraction at a Straight Wire
9. Young's Modulus By Cornu's Method
10. End Point Energy of Beta Particles
11. Energy Gap using Optical Method
12. Photodetector Characteristics

Additional experiments may be added

PS 576.3P Computational Physics Practicals

1. Basic C/C++ programmes to use for, while, do, switch, break, continue instructions.
2. Array, strings, functions, pointer programmes.
3. Programmes on basic Numerical techniques
4. Programmes to solve Schrödinger, heat and wave equations.

Additional programmes may be added.

PO 577.3 Experimental Techniques

Unit I Lasers and Nonlinear optics [13 hours]

Lasers: Introduction - directionality, intensity, monochromaticity, coherence. Some specific laser systems - Ruby laser, Neodymium lasers, He - Ne laser, ion lasers, CO_2 laser, Semiconductor lasers, Q switching.

Nonlinear 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.

Unit II Vacuum techniques [13 hours]

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.

Vacuum pumps - rotary vane pump (pumping speed and ultimate pressure), oil diffusion pump - baffle and trap, cryopump, turbomolecular pump.

Vacuum gauges - vacuum gauges and the relevant range of vacuum, Pirani gauge, thermocouple gauge, Penning gauge, hot cathode ionisation gauge.

Unit III Microstructure study techniques [13 hours]

TEM: Principle and components, imaging method. Contrast formation, sample parameters, Application, limitation.

SEM: Principle, components, image contrast, Application , limitation.

Atomic force microscopy: Principles, imaging modes, advantages and disadvantages.

X-ray Photoelectron spectroscopy: Principles, components. (XPS/ESCA).

Energy dispersion spectroscopy (EDS).

Electron probe micro analysis (EPMA).

Low energy electron diffraction (LEED).

Reference Books:

1. Silfvast W T, ‘Laser Fundamentals’, (Cambridge University Press, 1998)
2. Ghatak A K, Thyagarajan K, ‘Optical Electronics’, (Cambridge University Press, 1991)
3. Laud B B, ‘Lasers and Nonlinear Optics’, (Wiley Eastern, 1985)
4. Mills D L, ‘Nonlinear Optics – Basic Concepts’, (Narosa Publishing, 1991)
5. Boyd R W, ‘Non Linear Optics’, (Academic Press, 1992)

6. Shen Y R, 'The Principles of Non Linear Optics', (Wiley, 1984)
7. Saxby G, 'Practical Holography', (Taylor & Francis, 2003)
8. Roth A, 'Vacuum Technology', (III Edn. Elsevier, 2012)
9. Umrath W, 'Fundamentals of Vacuum Technology Technology', (Oerlikon Leybold, 2007)
10. Hata D M, 'Introduction to Vacuum Technology', (Prentice Hall, 2007)
11. Smallman R E, Ngan A H W, 'Physics Metallurgy and Advanced Materials', (Butterworth, 2011)
12. Ray F Egerton, 'Physical Principles of Electron Microscopy - An Introduction to TEM, SEM and AFM', (Springer, 2005)
13. Williams D B, Carter C B, 'Transmission Electron Microscopy: A Textbook of Materials Science (Four Volumes)', (Springer, 2008)
14. Leng Y, 'Materials Characterisation', (Wiley, 2008)
15. Goodhew P, Humphreys J, Beanland R, 'Electron Microscopy and Analysis', (Taylor & Francis, 2000)
16. Suryanarayana C, 'Experimental Techniques in Materials and Mechanics', (CRC Press, 2011)
17. Zhang S, Li L, 'Materials Characterization Techniques', (CRC Press, 2008)

Semester IV

PH 571.4 Atomic and Molecular Physics

Unit I Atomic Spectra: [13 hours]

Atomic spectra and the Bohr model for hydrogen, Vector atom model, Quantum Numbers, Moseley's law, The Stern-Gerlach Experiment- Angular momentum and Spin, X-ray spectra. Fine structure, Hyperfine structure, Lamb effect, Zeeman effect , Stark effect, LS Coupling, jj coupling.

Unit II One electron and many electron atomic systems [13 hours]

Hydrogenic atoms, Schrodinger equation for one-electron atoms, Interaction of Hydrogenic atoms in an electromagnetic field, Transition rates: spontaneous absorption, stimulated emission, spontaneous emission, dipole approximation. Line shape and line width, line broadening mechanisms (qualitative). The central field approximation for many electron atoms.

Unit III Microwave, Infrared and Electronic spectroscopy [13 hours]

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

Unit IV Raman and Spin Resonance Spectroscopies [13 hours]

Raman Spectroscopy: Light scattering and Raman effect, classical model for scattering, Stokes and anti - Stokes lines, polarizability, instrumentation.
Spin Resonance Spectroscopies: nuclear spin and electron spins, effect of applied external fields, Nuclear Magnetic Resonance (NMR) spectroscopy, Electron Spin Resonance (ESR) spectroscopy, basic principles and examples, instrumentation. Mossbauer Spectroscopy: Principles and Applications, instrumentation.

Reference books:

1. Brandsen B H, Joachaim C J, 'Physics of atoms and molecules', (Longman, 1983)

2. Eisberg R, Resnick R, 'Quantum Physics of Atoms, Molecules, Solids, Nuclei and Particles', (II Edn. John Wiley & Sons, 2010)

3. Sakurai J J, 'Modern Quantum Mechanics', (II Edn. Pearson, 2011)
4. Cohen Tannoudji C, Diu B, Laloë F, 'Quantum Mechanics (2 volumes)', (Wiley)
5. Banwell C N, McCash E M, 'Fundamentals of Molecular Spectroscopy', (IV Edn. Tata McGraw Hill, 1994)
6. Michael Hollas J, 'Modern Spectroscopy', (IV Edn. Wiley India, 2010)
7. Aruldhas G, 'Molecular Structure and Spectroscopy', (Prentice Hall of India, 2002)
8. Herzberg G, 'Molecular Spectra and Molecular Structure, Vol. I, II & III', (Van Nostrand Co., 1966)
9. Max Born, 'Atomic Physics', (VIII Edn. Dover, 1989)
10. Herzberg G, 'Atomic Spectra and Atomic Structure', (Dover, 1944)
11. Ghoshal S N, 'Atomic and Nuclear Physics', Vol I and Vol II (S Chand and Co., 1994)

PH 572.4 Nuclear and Particle Physics

Unit I General properties of the nucleus and nuclear decay [13 hours]
Constituents of nucleus and their properties. Mass of the nucleus - binding energy. Charge and charge distribution. Size - estimation and determination of the nuclear radius. Nuclear radius from mirror nuclei - spin statistics and parity. Magnetic moment of the nucleus. Quadrupole moment.
Nuclear decay - Alpha decay - quantum mechanical tunnelling - wave mechanical theory. Beta decay - continuous beta ray spectrum - neutrino hypothesis. Fermi's theory of beta decay - Curie 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 radiation with matter and radiation detectors [13 hours]
Energy loss of charged particles in matter, Bethe - Bloch formula. Interaction of gamma rays - interaction mechanisms - photoelectric absorption, Compton scattering, Klein - Nishina formula (qualitative discussion) pair production processes, Gamma ray attenuation - attenuation coefficients, absorber mass thickness, cross sections. Interaction of neutrons - general properties - slow down interaction, fast neutron interaction, neutron cross sections.
Radiation detectors - gas filled counters, Scintillation detectors, Semiconductor detectors. Neutron detectors.

Unit III Nuclear forces and nuclear models [13 hours]
Nature of nuclear force - short range, saturation, spin dependence and charge independence. Ground state of the deuteron using square well potential - relation between range and depth of the potential. Yukawa's theory of nuclear forces and explanation of anomalous magnetic moment of the nucleus.
Review of nuclear models - liquid drop model - semi empirical mass formula - stability of the nuclei against beta decay - mass parabola. Shell model (qualitative treatment).
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.

Unit IV Particle Physics [13 hours]
Classification of fundamental forces.Conservation laws and basic interactions relating to elementary particles - particles and antiparticles. Quarks, baryons mesons, leptons. Properties of particles - spin and parity assignments, isospin, strangeness.
Gell-Mann-Nishijima formula, C, P and T invariance, CP violation, the CPT

theorem. Applications of symmetry arguments to particle reactions, parity non conservation in weak interactions.

Reference books:

1. Krane K S, 'Introductory Nuclear Physics', (John Wiley, 1988)
2. Patel S B, 'Nuclear Physics - An Introduction', (Wiley Eastern, 1991)
3. Roy R K, Nigam P P, 'Nuclear Physics - Theory and Experiment', (Wiley Eastern Ltd., 1993)
4. Evans R D, 'The Atomic Nucleus', (Kreiger, 2003)
5. Friedlander G, Kennedy J W, Macias E S, Miller J M, 'Nuclear and Radiochemistry', (John Wiley, 1981)
6. Knoll G F, 'Radiation Detection and Measurement', (II Edn. John Wiley, 1989)
7. Kapoor S S, Ramamurthy V S, 'Nuclear Radiation Detectors', (New Age International, 1986)
8. Singru R M, 'Introduction to Experimental Nuclear Physics', (Wiley Eastern, 1975)
9. Segre E, 'Nuclei and Particles', (W A Benjamin Inc., New York, 1965)
10. Griffiths D J, 'Introduction to elementary particles', (II Rev Edn. Pearson, 2001)

PH 573.4P Project

Guidelines for the preparation, presentation and evaluation of students research projects in semester IV (Science Faculty)

Preamble

Research based learning has become an integral part of education at higher level. Autonomy provided to the college has created opportunities for introducing innovativeness through effective learning. In this regard, the choice based credit system introduced to postgraduate programmes from the year 2016-17 has introduced the concept of project work in the fourth semester for four credits.

Research projects play an important role in the curriculum, wherein students develop a research culture by going through the published research articles, documents, choosing a relevant problem, preparing and collecting relevant materials/samples, analyzing and characterising them to arrive at their own findings and conclusions. It is a work that a student must do largely under his / her own direction, in the field of the chosen area, however faculty members will extend their help and guidance towards the implementation of the project work.

This guideline describes the procedures to be followed in the due course of implementation of the project. It outlines the general rules and regulations which govern the project, in terms of research work both theoretical and experimental, preparation of thesis and presentation/publication.

Planning the Project Work

The Students are advised to begin choosing relevant area of their interest during the third semester itself. However by the end of third semester he/she should meet the Head of the department with few project plans of his choice in the order of priority.

Allotment of the Project Work

By the end of third semester, the Head of the department in consultation with other members of his/her department, study the feasibility of the student's proposal in terms of materials(chemicals), facility, space and cost effectiveness, expertise in the relevant area etc. and allot a group of students to a particular project and a supervisor. By and large student's selected area is allotted without any bias.

The Role of Supervisor

The supervisor will be able to advise the student about all aspects of the project as it unfolds. He/she must be able to foresee the relevance, applicability and its uniqueness. He will constantly monitor the progress and the quality of the work and give appropriate direction as and when it demands through his/her availability in the department/Lab. He/she also should make the student aware of inadequate progress or any other facts which could impede the completion of a successful piece of work.

Responsibilities of the Student

A student should spend a minimum of 8 hours for the project in the library by referring the articles or in laboratory by doing the experimental work in a week throughout the fourth semester. Student should try to keep supervisor informed about the progress and plans in respect of the project. To make appointments with the supervisor on a regular basis, if he/she is facing difficulty in arranging appointments he/she must contact the Head of Department.

Student should submit at least two written progress reports prior to the presentation in the department. Students should accept the constructive criticism of the supervisor in the point of improving the quality of research work of his/her project.

Assessment
Internal (Out of 30):

1. Action plan: Review of literature/ plan of work/ Synopsis: **10 marks**
2. Actual work, results, interactions and regular submission of reports: **10 marks**
3. Presentation in front of all members of the department before preparing the final thesis; (The faculty members may fine tune or give suggestions to improve the quality of final work at this stage): **10 marks**

External examination

External examination will be conducted in a similar manner to practical examinations. A group of 10-12 students allotted to a batch. One internal and one external examiner approved by Board of studies of the concern department will conduct viva-voce.

The marks are distributed as follows (out of 70)

- Thesis (report) content: **45 marks**
  (45 marks are split into 40+5; Out of 45 marks, 3 marks are allotted to the student, who present the paper in any conference and the remaining 2 marks are allotted for the student if he/she wins a prize in the paper presentation.)

- Presentation in the final examination: **15 marks**
- Viva-voce: **10 marks**

The student should prepare one or two (if demanded by the department) copies of the report which he/she can preserve for themselves after the final viva-voce.
Note: Due to lack of space to keep bound copies of the project reports, the department may instruct the students to submit the department (library) copy of the project report in compact disc (CD) form. However good projects (at least 3 to 5 in a year) which are worth referring can be preserved in the bound copy form in the department. The same can be used to present before committees (NAAC, DST, LIC etc.) at the time of inspection. This can be told to students in their pre-viva presentation (presentation in the department).

Project report format

COVER PAGE (AS PROVIDED)
FRONT PAGE (AS PROVIDED)
CERTIFICATE (AS PROVIDED)
ACKNOWLEDGEMENT
DECLARATION (AS PROVIDED)
CONTENTS

1. INTRODUCTION
2. REVIEW OF LITERATURE
3. AIM AND OBJECTIVE
4. METHODOLOGY / EXPERIMENTATION / MATERALS & METHODS
5. RESULTS and DISCUSSION
6. CONCLUSIONS
7. REFERENCES

- **Introduction**: This includes the background of the work, lacuna if any in previous work and importance of the present work. The last part of introduction must highlight the objectives. The objectives should give a clear picture of the project.
- **Review of Literature**: Includes the study and experimentation carried out by other workers on the topic which is being studied in the present project. The subheadings may be given at appropriate places for covering the topic under consideration. The subheadings may be appropriately numbered, for example, 2.1, 2.1.1, 2.2, etc. The literature must be cited with suitable references for example ($Subbiahetal.$, 2005), ($RaviandHarish$, 2009) etc.
- **Materials and Methods**: The write -up must include the Materials used for the project work. Brand names of equipments and chemicals need to be specified. The methodology must be described briefly (the main principle involved is sufficient) citing the reference from which it is based. Only if the method is new, give detailed explanation.

- **RESULTS AND DISCUSSIONS**: This chapter must include the results of the project developed. The results must be depicted as figure, tables, graphs etc. Also the results must be explained in words. The comparison of the results, statisitical significance of the results should be discussed in this chapter. The concluding remarks may be included specifying how the project can help the end user.
- **Conclusions**: This includes the end result derived from the project and any further scope of research which can be carried out using the present work.
- **References**: At the end of the report 30 to 50 references relevant to the topic chosen should be given. The style of reference can be chosen according to any good international journal of the concern PG program. It is left to the discretion of the department.

Examples to write the references

1 For references from journals:
Bhaghyesh et. al., "$\gamma\gamma$ and gg decays of χ_{c0} and χ_{c2}", *Archives of Physics Research*, (2010), 1 (4): 200-204.

2 For references from books:
Arfken G B, Weber H J, Harris F E, "Mathematical Methods for Physicists', VII Edn., Academic Press, (2013).

Cover Page

TITLE
(Times New Roman, Font size 20, Capitals, Bold)

A Project Report
Submitted by
(Times New Roman, Font 12)

NAME
(**Reg. No.**)
(Times New Roman, Font 12, Bold, Capital)

to

ST ALOYSIUS COLLEGE
(AUTONOMOUS)

In part fulfilment of the requirements for the award of
Master of Science
(Times New Roman, Font 16,)
PHYSICS
(Times New Roman, Font 16,Capital,)

Department of PG Studies and Research in Physics
(Times New Roman, Font 16)

April, 2018
(Times New Roman, Font 16)

Front page

TITLE
(Times New Roman, Font size 20, Capitals, Bold)

A Project Report
Submitted by
(Times New Roman, Font 12)

NAME
(**Reg. No.**)

Under the guidance of
NAME OF THE SUPERVISOR

to

ST ALOYSIUS COLLEGE
(AUTONOMOUS)

In part fulfilment of the requirements for the award of
Master of Science
PHYSICS
(Times New Roman, Font 16,)

Department of PG Studies and Research in Physics
(Times New Roman, Font 16)

April, 2018
(Times New Roman, Font 16)

CERTIFICATE

This is to certify that the project report entitled "————-**Title**—— ————" is a bonafied work carried out by ———**Name**————-, —- **Reg.No.**—- under the guidance of ———**Name of the Guide**——— in the **Department of PG Studies and Research in Physics**, **St Aloysius College**.

The same is being submitted to the Post Graduate Department of Department Name , St Aloysius College in partial fulfilment of the requirements for the award of **Master of Science - Physics**. No part of this thesis has been presented for the award of any other degree.

Name and Signature of HOD   Name and Signature of the Guide

ACKNOWLEDGEMENT

In the "Acknowledgement" page, the writer recognizes his/her indebtedness for guidance and assistance of the different persons and members of the faculty. Courtesy demands that he/she also recognize specific contributions by other persons or institutions such as libraries and research foundations/funding agencies. Acknowledgements should be expressed simply, tastefully, and tactfully.

DECLARATION

I/We, ——**Name**——— hereby declare that the project work entitled "——————————**Title**————" is my/our original work and has been carried out under the guidance of ————-**Name of the Guide**—————————, **PG Department of Physics**, **St Aloysius College** is being submitted to the **Department of PG Studies and Research in Physics** (**Department Name**), **St Aloysius College** in partial fulfilment of the requirements for the award of **Master of Science - Physics**.

I also hereby declare that this work, in part or full, has not been submitted to any other University/Institution for any Degree/Diploma.

Date of Submission:

Signature of the candidate
(NAME)
(Reg. No.)

Signature of the Supervisor
(NAME)

PS 574.4 Communication Theory

Unit I Transmission Lines [13 hours]
Distributed parameters, types of transmission lines, calculation of line parameters. Inductance and capacitance of parallel round conductors, coaxial cables. Voltage, current and impedance relations. Characteristic impedance, reflection coefficient, propagation constant. Line distortion and attenuation. Line parameters at high frequencies, Line termination. Standing wave ratio. Quarter and half wavelength lines. Impedance matching, quarter wave transformer, stub matching. Smith chart and its applications.

Unit II Wave guides and antenna [13 hours]
Basic concepts, guided waves between parallel planes. TE and 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.

Unit III Microwave devices and Satellite communication [13 hours]
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 and INSAT series.

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 G., Davis B., “Electronic Communication Systems”, IV Edn. (Tata McGraw Hill, 1993)

4. Roddy D., Coolen J., “Electronic Communications”, IV Edn. (PHI, 1995)

5. Kraus J D, Fleisch D A, "Electromagnetics with Applications", V Edn. (McGraw Hill, 1999)

6. Ghatak A K, Thyagarajan K, "Optical Electronics', (Cambridge University Press, 1991)

7. Taub H, Schilling D L, "Principles of Communication System", II Edn. (McGraw Hill, ISE, 1986)

8. Liao S Y, "Microwave Devices and Circuits", III Edn. (PHI)

9. Roddy D, "Satellite Communications", III Edn. (McGraw Hill, 2001)

PS 575.4 Lasers, Vacuum techniques and Nonlinear Optics

Unit I Lasers and Nonlinear optics [13 hours]
Lasers: Introduction. Some specific laser systems - Neodymium lasers, ion lasers, CO_2 laser, dye lasers, chemical lasers, X-ray lasers, free electron lasers, Q switching, mode locking.
Nonlinear 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.

Unit II Vacuum techniques [13 hours]
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.
Vacuum pumps - rotary vane pump (pumping speed and ultimate pressure), oil diffusion pump - baffle and trap, cryopump, turbomolecular pump.
Vacuum gauges - vacuum gauges and the relevant range of vacuum, Pirani gauge, thermocouple gauge, Penning gauge, hot cathode ionisation gauge.

Unit III Microstructure study techniques [13 hours]
TEM: Principle and components, imaging method. Contrast formation, sample parameters, Application, limitation.
SEM: Principle, components, image contrast, Application , limitation.
Atomic force microscopy: Principles, imaging modes, advantages and disadvantages.
X-ray Photoelectron spectroscopy: Principles, components. (XPS/ESCA).
Energy dispersion spectroscopy (EDS).
Electron probe micro analysis (EPMA).
Low energy electron diffraction (LEED).

Reference Books:

1. Silfvast W T, 'Laser Fundamentals', (Cambridge University Press, 1998)
2. Ghatak A K, Thyagarajan K, 'Optical Electronics', (Cambridge University Press, 1991)
3. Laud B B, 'Lasers and Nonlinear Optics', (Wiley Eastern, 1985)
4. Mills D L, 'Nonlinear Optics – Basic Concepts', (Narosa Publishing, 1991)
5. Boyd R W, 'Non Linear Optics', (Academic Press, 1992)

6. Shen Y R, 'The Principles of Non Linear Optics', (Wiley, 1984)
7. Saxby G, 'Practical Holography', (Taylor & Francis, 2003)
8. Roth A, 'Vacuum Technology', (III Edn. Elsevier, 2012)
9. Umrath W, 'Fundamentals of Vacuum Technology Technology', (Oerlikon Leybold, 2007)
10. Hata D M, 'Introduction to Vacuum Technology', (Prentice Hall, 2007)
11. Smallman R E, Ngan A H W, 'Physics Metallurgy and Advanced Materials', (Butterworth, 2011)
12. Ray F Egerton, 'Physical Principles of Electron Microscopy - An Introduction to TEM, SEM and AFM', (Springer, 2005)
13. Williams D B, Carter C B, 'Transmission Electron Microscopy: A Textbook of Materials Science (Four Volumes)', (Springer, 2008)
14. Leng Y, 'Materials Characterisation', (Wiley, 2008)
15. Goodhew P, Humphreys J, Beanland R, 'Electron Microscopy and Analysis', (Taylor & Francis, 2000)
16. Suryanarayana C, 'Experimental Techniques in Materials and Mechanics', (CRC Press, 2011)
17. Zhang S, Li L, 'Materials Characterization Techniques', (CRC Press, 2008)

PS 576.4 Condensed Matter Physics III

Unit I Thin films [13 hours]
Preparation techniques. Physical vapour deposition. Knudsen cosine law. Sputtering and chemical methods. Thickness measurement techniques - quartz crystal monitor.
Nucleation and growth, Capillary theory of nucleation. Growth stages and effect of deposition parameters. Electrical and optical properties of thin films. Conduction in thin films - a qualitative description. Reflectance and transmittance of light by thin films. Anti reflection coating, reflection coating and interference filters.

Unit II Super conductivity [13 hours]
Type I and Type II superconductors. Thermodynamics of superconductivity. London equations. Coherence length. Flux quantization, Cooper pairs. Accomplishments of BCS theory. Basic concept of tunnelling: metal – insulator - metal; metal - insulator - superconductor, superconductor - insulator - superconductor tunnelling. Cooper pair tunnelling. AC and DC Josephson effect. SQUIDS. High T_c superconductors. Applications.
Super fluids.

Unit III Smart materials and Nano Materials [13 hours]
Piezoelectric materials, smart polymers and gels, shape memory materials - alloys and polymers. Electro - rheostatic and magneto: rheostatic materials, magnetostrictive materials, electrogenic and chromogenic systems, electrochromic, thermochromic, photochromic materials, ferrofluids, Photomechanical materials, dielectric elastomers.
Nanostructural materials - metals, semiconductors and ceramics. Synthesis of nano particles - inert gas evaporation, laser pyrolysis - sputtering techniques, plasma techniques, chemical methods.
Functionalized metal nano particles - synthesis, characterization, organization and applications.

Reference books:

1. Goswami A, ‘Thin film fundamentals’, (New Age International, 1996)

2. Ohring M, ‘The Materials Science of Thin films’, (Academic Press, 1992)

3. Wagendristel A, Wang Y, ‘An Introduction to Physics and Technology of Thin Films’, (World Scientific, 1994)

4. Chopra K L, 'Thin Film Phenomena', (Kreiger Publ., 1979)
5. Callister W, Rethwisch D G, 'Materials Science and Engineering', (John Wiley, 2010)
6. Van Vleck L H, 'Elements of Materials Science and Engineering', (Pearson, 2002)
7. Smith W F, Hashemi J, Raviprakash, 'Materials Science and Engineering', (Tata McGraw Hill, 2008)
8. Ashcroft N W, Mermin N D, 'Solid State Physics', (Harcourt Asia, 1976)
9. Ibach H, Luth H, 'Solid state Physics', (Narosa, 1991)
10. Kittel C, 'Introduction to Solid State Physics', (VIII Edn. Wiley India, 2005)
11. Annet J F, Wills H H, 'Superconductivity, Superfluids and Condensates', (Oxford University Press, 2004)
12. Tinkham M, 'Introduction to Superconductivity', (II Edn., Dover, 2012)
13. Schwartz M, 'Encyclopedia of Smart Materials', (Wiley Interscience, 2005)
14. Radheshyam Rai, 'Synthesis, Characterisation and Apllications of Smart Materials', (Nova Science Publishing, 2012)
15. Culshaw B, 'Smart Structures and Materials', (Artech House, 1995)
16. Chattopadhyay K K, Bannerjee, A N, 'Introduction to Nanoscience and Nanotechnology', (PHI, 2007)
17. Charles P Poole Jr and Frank J Owens, 'Introduction to Nanotechnology', (Wiley Interscience, 2002)
18. Edward L Wolf, 'Nano Physics and Nanotechnology', (II Edn. Wiley VCH, 2006)

PS 577.4 Nuclear Structure

Unit I Deuteron problem and Nuclear Forces [13 hours]

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.

Unit II Nuclear Scattering [13 hours]

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. Experimental results. High energy n-p scattering and experimental results.

Unit III Nuclear Models [13 hours]

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

Reference books:

1. Roy R R, 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 and Company, 1994)
4. Singru R M, 'Experimental Nuclear Physics', (Wiley Eastern, 1972)
5. Krane K S, 'Introductory Nuclear Physics', (John Wiley, 1986)

6. Evans R D, 'Atomic Nucleus', (Tata McGraw Hill, 1972)
7. Kapoor S S, Ramamoorthy V S, 'Radiation Detectors', (Wiley Eastern, 1986)

PS 578.4P General Physics Experiments - IV

1. Zeeman effect
2. Verdet's Constant
3. Freedericksz Transition
4. Temperature Dependence of Hall Coefficient
5. Thermal Expansion of a Crystal using Optical Interferometry
6. Magnetoresistance
7. Hysteresis Loop Tracer
8. Junction capacitance of a p-n diode
9. Fabry - Perot Interferometer
10. Fermi Energy of metal
11. Electron Spin Resonance
12. Gamma ray spectrometer
13. Four probe method

Additional experiments may be added

General Reference:

1. 'C R C Handbook of Chemistry and Physics', (94^{th} Edn. C R C Press, Taylor and Francis Group, 2014)
2. Halliday D, Resnick R, Walker J, 'Fundamentals of Physics', (Extended IX Edn. Wiley India, 2011)
3. Young H D, Freedman R A, 'Sears and Zemansky's University Physics with Modern Physics', (XIII Edn., Pearson, 2012)
4. Alonso M, Finn E J, 'Physics', (Pearson, 2012)
5. Beiser A, 'Concepts of Modern Physics', (VI Edn., Tata McGraw Hill, 2003)
6. Krane K, 'Modern Physics', (III Edn., Wiley Inc., 2012)
7. Jenkins F A, White H E, 'Fundamentals of Optics', (McGraw Hill, 1974)
8. Hecht E, 'Fundamentals of Optics', (Addison Wesley, 2002)
9. Weinberg S, 'First Three Minutes: A Modern View of the Origin of the Universe', (Basic Books, 1993)

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