SYLLABUS

PHYSICS

(Semester Scheme)

M.Sc. (Previous) Examination, 2015
M.Sc. (Final) Examination, 2016

JAI NARAIN VYAS UNIVERSITY
JODHPUR

Department of Physics

Located on the beautiful campus of Jai Narain Vyas University, Jodhpur, the Department of Physics started its activities in July 1962 and there is no looking back since then. Headed by Prof Krishnan to begin with, the department today is an active beehive of students.

The department offers a 3-year B.Sc. programme in Physics, computer science and electronics. It also offers a 2-year M.Sc. programme in Physics (Semester Scheme), which has been newly introduced from the session 2013-14. Our first batch in Semester scheme shall be passing out in session 2014-15. In current session, we are running M.Sc. Final programme in old annual scheme also. The Department also offers an active and sought after Ph.D. programme, in which over about 25 research students are currently enrolled.

JNV University being Divisional and the largest University in Western Rajasthan, offers research facilities, a high quality post graduate, doctoral and post doctoral programme. The research programs of the Department cover a number of areas like condensed matter physics, dielectrics and nano science, solar cell & related physics, material science, quantum optics, Mossbauer Spectroscopy etc.

There are Defence Research & Development Organisation (DRDO) and MBM Engineering College in Jodhpur and that goes a long way in promoting quality research in various fields.

The department has about seventeen active faculty members, some research associates who undertake cutting edge research on various active fields in physics. It also has couple of state-of-the-art laboratory facilities to support the research work in the fields in house or available at DRDO and MBM Engineering College.

The department has received funds from DST- government of India under the FIST program. UGC has also offered BSR fellowships to almost all research scholars of this Department.

FACULTY MEMBERS

S.No.	Name of Teacher	Area of Specialization
1.	Prof. (Mrs.) Sushma Arora (Head)	X-Ray, Atomic Spectroscopy
2.	Prof. D.K. Sharma	Atomic Physics, Computational Physics
3.	Prof. R.J. Sengwa	Electronics, dielectric relaxation spectroscopy, material science, polymeric nanocomposites and solid electrolytes
4.	Prof. S.K. Sharma	Solid State Physics, Electronics
5.	Dr. (Mrs.) Beena Bhatia	Molecular Spectroscopy
6.	Dr. R.S. Singh	Solid State Physics, Condensed Matter Physics
7.	Dr. H.S. Singh	Mossbauer Spectroscopy
8.	Dr. K.R. Patel	Mossbauer Spectroscopy, X-Ray
9.	Dr. A.K. Gupta	Molecular Spectroscopy
10.	Dr. K. Dhoot	X-Ray, Mossbauer Spectroscopy
11.	Dr. Sahi Ram	Mossbauer Spectroscopy
12.	Mr. Giriraj Chayal	Solid State Physics
13.	Mr. S. S. Meena	Molecular Spectroscopy
14.	Mr. S. L. Meena	Molecular Spectroscopy
15.	Dr. Manu Smrity	Semiconductor Electronics
16.	Dr. Uttam Paliwal	Condensed Matter Physics, Computational Material Science
17.	Dr. Shiv Kumar Barwar	Condensed Matter Physics

MASTER OF SCIENCE (M. Sc.)

PHYSICS

General Information for Students

M. Sc. Physics is a two years Post Graduate Degree Course, comprising of four Semesters – for regular students. There will be two Semesters in each year (academic session). M. Sc. I Year will be comprised of Semester I and Semester II. Similarly M. Sc. II year will be comprised of Semester III and Semester IV. Each Semester will be of 15 weeks and the course will be covered in fixed number of contact hours of 45 minutes, referred to as periods per week (Pds/Wk). In each Semester the performance of the students will be assessed through Internal Evaluation (IE) and the End Semester Examination (ESE). The nomenclature of papers along with Teaching Scheme, Optional Elective Courses, Examination scheme, Minimum Pass Marks and Division are given below.

M.Sc. Physics
First Year (2015)
(Two Semesters each of 15 Weeks)

1. Nomenclature and Teaching scheme of M.Sc. I year.

I Semester

THEORY PAPERS	**Pds / Wk**	**IE**	**ESE**	**TOTAL**
PH-401 Classical Mechanics	4	50	50	100
PH-402 Waveform Generators & Electronic Instrumentation	4	50	50	100
PH-403 Mathematical methods in Physics	4	50	50	100
PH-404 Quantum Mechanics	4	50	50	100
PH-405 Computational Physics	4	50	50	100
TOTAL MARKS- THEORY				500
PRACTICALS (LABORATORY COURSES)	**Pds / Wk**	**IE**	**ESE**	**TOTAL**
PH-406 Electronics Laboratory	12	45	80	125
PH-407 Computational Physics Laboratory I	12	45	80	125
TOTAL MARKS - PRACTICALS				250
TOTAL MARKS OF I SEMESTER				**750**

II Semester

THEORY PAPERS	**Pds / Wk**	**IE**	**ESE**	**TOTAL**
PH-408 Numerical Methods	4	50	50	100
PH-409 Advanced Quantum Mechanics	4	50	50	100
PH-410 Classical Electrodynamics	4	50	50	100

PH-411 Solid state Physics	4	50	50	100
PH-412 Nuclear Physics I	4	50	50	100
TOTAL MARKS- THEORY				500
PRACTICALS (LABORATORY COURSES)	**Pds / Wk**	**IE**	**ESE**	**TOTAL**
PH-413 General Physics and Laser Laboratory	12	45	80	125
PH-414 Computational Physics Laboratory II	12	45	80	125
TOTAL MARKS- PRACTICALS				250
TOTAL MARKS OF II SEMESTER				**750**
TOTAL MARKS OF M. Sc. I YEAR				**1500**

M.Sc. Physics
Second Year (2016)
(Two Semester each of 15 Weeks)

2. Nomenclature and Teaching scheme of M.Sc. II year.

III Semester

THEORY PAPERS	Pds / Wk	IE	ESE	TOTAL
PH-501 Condensed Matter Physics	4	50	50	100
PH-502 Communication and Microwave Electronics	4	50	50	100
PH-503 Statistical Physics	4	50	50	100
PH-504 Atomic and Laser Physics	4	50	50	100
PH-505 Nuclear Physics II	4	50	50	100
TOTAL MARKS- THEORY				500
PRACTICALS (LABORATORY COURSES)	**Pds / Wk**	**IE**	**ESE**	**TOTAL**
PH-506 Communication and Microwave Electronics Laboratory	12	45	80	125
PH-507 Nuclear and Condensed Matter Laboratory	12	45	80	125
TOTAL MARKS - PRACTICALS				250
TOTAL MARKS OF III SEMESTER				**750**

IV Semester

THEORY PAPERS	Pds / Wk	IE	ESE	TOTAL
PH-508 Advanced Condensed Matter Physics	4	50	50	100
PH-509 Digital Electronics and Microprocessor	4	50	50	100
PH-510 Electrodynamics and Plasma Physics	4	50	50	100
PH-511 Molecular and Resonance Spectroscopy	4	50	50	100
PH-512 A-I (2 Optional Elective Courses-to be chosen from point 3 below) Elective Course-1 Elective Course-2	2 2	30* 30*	20** 20**	100

TOTAL MARKS- THEORY				500
PRACTICALS (LABORATORY COURSES)	**Pds / Wk**	**IE**	**ESE**	**TOTAL**
PH-513 Digital Electronics and Microprocessor Laboratory	12	45	80	125
PH-514 Atomic and Molecular Spectroscopy Laboratory	12	45	80	125
TOTAL MARKS - PRACTICALS				250
TOTAL MARKS OF IV SEMESTER				**750**
TOTAL MARKS FOR M.Sc. II YEAR				**1500**
TOTAL MARKS FOR M.Sc. Two Years Degree Course				**3000**

* Shall be equally divided in Lecture Ability and Short Term report as detailed under point 4 below.

** Shall be based on End Term Test of 2 hours as detailed under point 4 below.

3. Optional Elective Courses

PH-512 Elective Course (512A – 512I)

In all, nine courses are defined which will be a kind of self study courses. Each candidate will opt for two such courses. Contact hours for each course will be of two periods, with one of the faculty members. In this students will be delivering lectures on elective courses chosen, writing short reports on some part of the courses defined in the syllabus and will appear for end term test of 2 hrs. For these optional courses, teaching and marking scheme shall be as per table below:

PH-512	Periods/ week	Lecture Ability	Short Report	End Term Test	Total
Elective -1	2	15	15	20	50
Elective -2	2	15	15	20	50

Elective Options:

PH-512A: Glasses,

PH-512B: Fundamental Astronomy,

PH-512C: Dielectric Spectroscopy,

PH-512D: Advanced Computational Physics,

PH-512E: Soft X-ray Spectroscopy,

PH-512F: Non Linear Dynamics and Chaos,

PH-512G: The General Theory of Relativity,

PH-512H: Quantum Optics,

PH-512 I: Radiation Physics.

4. Examination Scheme for ESE and IE

ESE (End Semester Examination)

- In the University Examination mentioned ESE (End Semester Examination) in Theory Papers, each theory paper shall be of 3 hours duration. Each paper will be divided into five units as in syllabus. Two questions will be set from each unit. Students will attempt 5 questions selecting one question from each unit. All the theory papers shall be set as per University rules. To the best possibility, it will be kept 100% external.

- In the University Examination mentioned as ESE (End Semester Examination) in Practicals (Laboratory Courses) each Practical exam shall be of 5 hrs duration and Board of examiners shall be appointed as per University rules. Evaluation shall be based on performance of experiment (50 marks) and viva voce (30 marks) out of 80 marks.

IE (Internal Evaluation)

- In Internal Evaluation (IE), each theory paper shall be evaluated through three quizzes, two term tests and seminar. Out of three quizzes the best two shall be considered. Seminar will be a part of theory syllabus. Two students can work together for one seminar. A written document of 5-10 pages should be submitted for Internal Evaluation.

- Internal evaluation in each theory paper (maximum marks 50) will be done according to following scheme:

○ Each quiz of 15 marks (30 minutes each) For 2 Quiz (2x15)	=	30
○ Seminar Presentation (15 minutes each)	=	20
○ One Mid Term Test (1 hour each)	=	20
○ One End Term Test (2 hours each)	=	30
TOTAL		**100**

  These marks out of 100 should be reduced to marks out of 50.

- In IE for Practicals (Laboratory Courses), the IE will be based on regularity i.e. attendance (15 marks), day to day performance in Laboratory (10 marks) and File making (20 marks) out of 45 marks.

Minimum Pass Marks and Division

- Minimum pass marks for each theory paper will be 30%, each in internal evaluation (IE) and End Semester Examinations (ESE) separately.

- Minimum pass marks for each Practical Examination will be 40%.

- A candidate must get 40% marks in aggregate in theory papers and 40% marks in each Practical Examination for passing each Semester examination.

- The successful candidates shall be awarded division as per following scheme, after completion of IV semester examination.

I Division	–	60% and above.
II Division	–	48% and above but less than 60%.
III Division	–	40% and above but less than 48%.

- There shall be no supplementary examination, however student will be eligible for just one back paper in I semester and another back paper in II Semester. These back papers in each Semester can either be in Theory or Laboratory courses. The candidate will have to clear these back papers while appearing for III and IV Semesters respectively. No back papers will be given in Semester III and IV.

- All students of I-Semester shall be provisionally admitted to II-Semester and these students will appear for all examinations of II-Semester, irrespective of their results of I-Semester. All these students will be eligible for one back paper in each Semester as already defined.

5. **Status for Ex-Students**

- Any student failing in any of the I or II Semester or both Semesters, in an academic session, shall be an Ex-Student in the next academic session. He/ She will be appearing either in I or II or both Semesters as per his/ her result of previous academic session. The above condition will also be valid for the students of III and IV Semesters.

- An Ex-student will be eligible to appear only in ESE for all Theory and Laboratory Courses. Their marks in IE shall be carry forwarded to complete his/ her evaluation of that session.

M.Sc. Physics
M.Sc. I Year (2015)
Semester I

PH-401 CLASSICAL MECHANICS

UNIT-1

Constraints, holonomic and non-holonomic constraints, D'Alembert's Principle and Lagrange's Equation, velocity dependent potentials, simple applications of Lagrangian formulation. Hamilton Principle, Calculus of Variations, Derivation of Lagrange's equation from Hamilton's principle. Extension of Hamilton's Principle for non-conservative and non-holonomic systems.

Conservation theorems and Symmetry Properties, Conservation of energy, linear momentum and angular momentum as a consequence of homogeneity of time and space and isotropy of space.

UNIT-2

Rigid body motion: Angular momentum and kinetic energy of motion about a point, The inertia tensor and moment of inertia, eigen value of inertia tensor and principal axis transformation, Euler equation of motion for rigid body. Force free motion of rigid body.

UNIT-3

Generalized momentum, Legendre transformation and the Hamilton's Equations of Motion, simple applications of Hamiltonian formulation, cyclic coordinates, Routh's procedure, Hamiltonian Formulation of Relativistic Mechanics, Derivation of Hamilton's canonical Equation from Hamilton's variational principle.

UNIT-4

Canonical transformation, integral invariant of Poincare: Lagrange's and Poisson brackets as canonical invariants, equation of motion in Poisson bracket formulation. Infinitesimal contact transformation and generators of symmetry, Liouvilee's theorem, Hamilton-Jacobi equation and its application.

UNIT-5

Action angle variable adiabatic invariance of action variable: The Kepler problem in action angle variables, theory of small oscillation in Lagrangian formulation, normal coordinates and its applications.

Books Suggested

H. Goldstein, Classical Mechanics, Addison and Wesley (1985).
L Landau and E M Lifshitz - Classical Mechanics, Pergamon Press (1981).
A. Raychoudhary - Classical Mechanics
S.N.Biswas, Classical Mechanics, Books and Allied, Kolkata (2004).
N. C. Rana and P. S. Joag, Classical Mechanics, Tata McGraw Hill (1991).

PH-402 WAVEFORM GENERATORS AND ELECTRONIC INSTRUMENTATION

UNIT-1

Full wave bridge rectifier circuit, various filters and their working, transistor regulator, IC voltage regulators (78XX, 79XX and LM317), switching action of PN junction diode and transistor, diode reverse recovery time and its measurements.

UNIT-2

Feedback amplifiers: Advantages and disadvantages of negative feedback, circuits of voltage and current series negative feedback amplifier, RC phase shift oscillator, Wein bridge oscillator, Hartley and Colpitt's oscillators, astable multivibrator, UJT relaxation oscillator, voltage and current sweep generators.

UNIT-3

Block diagram of standard signal generators, FETVM, digital multimeter, frequency counter, harmonic distortion analyser, block diagram of CRO and its uses in amplitude, frequency and phase measurements.

UNIT-4

Transducers, block diagram of analog and digital data acquisition system, multiplexers radiation counter, SCA, MCA, IC555 and its use in square and triangular waveform generator, Fourier analysis of square wave.

UNIT-5

Op Amp basics, virtual ground concept, inverting and non-inverting Op Amp voltage gain, circuits of Op Amp sign changer, constant multiplier, adder, subtractor, integrator, differentiator, comparator and waveform generator.

Books suggested

Allen Mottershead, Electronic Devices and Circuits, PHI
A.D. Helfrick and W.D. Cooper, Modern Electronic Instrumentation and Measurement Techniques, PHI
Jacob Millman and Herbert Taub, Pulse, Digital and Switching Waveforms, TMH
Robert Boylestad and Louis Nasheslsky, Electronic Devices and Circuits, PHI
R.A. Gayakwad, Op-Amps and Linear Integrated Circuits, PHI
Abraham Pallas, Electronic devices and circuit Analysis, CBS
NN Bhargava, DC Kulshreshtha, SC Gupta, Basic Electronics and Linear Circuits, TMH

PH- 403 MATHEMATICAL METHODS IN PHYSICS

UNIT-1

Complex variables : Analytical functions, Cauchy Riemann conditions, Cauchy's integral theorem. Cauchy's integral formula. Taylor and Laurent's Series expansions, Cauchy's residue theorem.

UNIT-2

Fourier & Laplace transforms:

Fourier integral and Fourier transform, Convolution theorem, Laplace transform of derivatives, Substitution properties of Laplace transform, Properties of gamma function, error function and Dirac delta functions.

UNIT-3
Orthogonal Curvilinear coordinates: Gradient, Curl, Divergence and Laplacian in orthogonal Curvilinear coordinate systems, Cartesian, Spherical, Polar and Cylindrical as special case of orthogonal curvilinear coordinates.

UNIT-4
Partial differential equations in Physical Problems: Solution of Laplace differential equations, two dimensional steady flow of heat (Cartesian coordinates), Solution of two dimensional Laplace's equation in the cylindrical coordinates, Solution of general cylindrical Laplace's equation.

UNIT-5
Special functions: Series solution of the Linear differential equations with variable coefficients, Legendre, Bessel, Hermite, Laguerre, Associated Laguerre Polynomials and their generating functions, recurrence relations, orthogonal properties and Rodrigue's formula.

Books Suggested

G. Arfken and H.J. Weber, Mathematical Physics, Academic Press, (2005).
A.K. Mukhopadhyay, Mathematical Methods for Engineers & Physicists, (2010).
B.S. Rajput, Mathematical Physics, Pragti Prakashan, Meerut, (1997).
L.A. Pipes, Applied Mathematics for Engineers & Physicists, McGraw Hill, (1970).
M.C. Potter and J.L Goldberg, Mathematical Methods, Prentice Hall of India, (1978).
B.D. Gupta, Mathematical Physics , Vikas Publication House, (1986).
H.K. Das, Advanced Engineering Mathematics, S. Chand Pub, (2008).

PH 404 QUANTUM MECHANICS

UNIT-1
Complex linear vector space, states, amplitude and operators: Complex linear vector space, linearly independent basis vectors, dimension of vector space, scalar product of two vectors, Bra and Ket vectors, resolution of unit operators using Bra and Ket vectors and completeness relation .Operators in quantum mechanics, observables, Hermitian, Unitary and Projection operators. Commutation relations, process of measurement and central concepts of quantum mechanics.
Matrix representation of operators, Unitary transformations, Diagonalization of Observable operators, Illustration using two state systems.
Coordinate and momentum representation, Gaussian wave packets, Compatible and incompatible observables, simultaneous eigenkets of maximum set of compatible observables, Heisenberg uncertainty principle.

UNIT-2
One dimensional simple harmonic oscillator, eigenkets and eigenvalues by operator method, creation and annihilation operators, eigenkets in coordinate representation
Schrodinger picture, Heisenberg picture and Interaction picture.

Identical particles: The identity of particles, the indistinguishability principle, symmetry of wave function, spin and statistics, the Pauli's exclusion principle.
Variation Method: Principle and application to linear harmonic oscillator and Helium atom.

UNIT-3
Time independent perturbation theory: Non degenerate case, simple applications including anharmonic oscillator (x^4 potential) and linear harmonic oscillator. Degenerate case-applications to linear stark effect and Zeeman effect in Hydrogen atom
Time independent perturbation theory: Constant perturbation, Transition to continuum, Fermi's golden rule, harmonic perturbation, radiative transition in atoms.

UNIT-4
Symmetries and Angular Momentum: Symmetry transformation and conservation laws, invariance under space translation, space rotation and and time translation. Conservation of momentum, energy and angular momentum.
Angular momentum operators and their Eigenvalues and their eigenstates (angular momentum states), matrix representations of the angular momentum operators and their eigenstates, coordinate representations of the orbital angular momentum operators and their eigenstate (Spherical Harmonics).
Solution of Schrodinger equation for hydrogen atom, energy levels and stationary wave functions.

UNIT-5
Addition of angular momenta, Clebsch-Gordon (C.G) Coefficients, C.G coefficients for addition of j_1=1/2 and j_2=1/2. Tensor operators and Wigner Eckart theorem, Tensor operators for Electric dipole, electric quadrupole, and magnetic dipole operators. Expectation values of these operators for angular momentum states and selection rules for electric dipole, electric quadrupole and magnetic dipole transitions.

Books Suggested

Ashok Das and A.C.Melissions, Quantum Mechanics-A modern approach, Gordon & Breach Science Publication.
Ghatak and Loknathan, Quantum Mechanics-Theory and Applications, Macmillan (2010),
V.K. Thankappam, Quantum Mechanics, New Age International (1985).
J.J. Sakurai, Modern quantum Mechanics, Addison Wesley (1999).
L.I. Schiff, Quantum Mechanics, McGraw-Hill (1988).

PH-405 COMPUTATIONAL PHYSICS

UNIT-1
Problem solving through computers, algorithms, flow charts, programming languages, low level and high level language, interpreter and compilers, program development procedures. Errors in numerical calculations: Fixed and floating point representation, consequences of floating point arithmetic, rounding off of numbers, absolute and relative errors. Errors in computation: syntax error, logical error, error due to finite storage and approximation of infinite processes.

UNIT-2

Programming language C: Data types, qualifiers, constants, identifiers, variables, variable declaration, arithmetic operators: binary and unary operators, expressions. Preprocessor directives, including header files, library functions. Data input and output: getchar and putchar, scanf, control string, conversion characters, formatting input, field width, printf, conversion character and escape sequence, formatting output, field width and precision parameters, use of flags, string input/ output, gets and puts.

UNIT-3

Relational operators, relational expressions, logical operators transfer of control: if – else and switch-case statements. Repetitive statements: for loop, while and do- while statements, nesting of loops, continue and break statements. Arrays in C: one dimensional and multidimensional arrays, defining, declaring and initializing arrays.

UNIT-4

Functions in C program: Storage classes, static and external variable declaration, main function, return statement, defining a function, function declaration, function call, function prototype, passing arguments to a function, local and global parameters, call by value and call by reference, passing arrays to a function, recursion, static and external function definition.

UNIT-5

Pointers in C: pointer data type, declaration of pointers, indirection, operation on pointer variables, pointers and arrays, dynamic memory allocation , malloc function, pointer to array and array of pointers, pointer to a function. Files in C: opening and closing a data file, creating a data file, processing a data file.

Books Suggested

Rajaraman, Computer Programming in C, Prentice Hall of India

B. Gottfried, Programming with C, Schaum's Outline Series, Tata McGraw Hill

E. Balguruswamy, Programming in ANSI C, Tata McGraw Hill

E.V. Krishnamurthy and S.K. Sen, Numerical Algorithms, Affiliated East-West Press Pvt. Ltd., New Delhi.

PH-406 ELECTRONICS LABORATORY

1. Design and study of dc power supply with various filters and IC regulator.
2. Design and study of Op Amp differentiator, integrator and log amplifier circuit.
3. Design and study of different voltage gain inverting Op Amps and its frequency response.
4. Waveform study of an astable multivibrator.
5. Frequency response and input and output impedance study of current series negative feedback amplifier.
6. Fourier analysis of a square wave, triangular wave and half rectified wave.
7. Design and study of UJT saw tooth waveform generator.

8. Carriers life time measurements by reverse recovery and open circuit method.
9. Design and study of diode and transistor switching behavior and their operating point.
10. Design and study of RC phase shift oscillator/ Wein bridge oscillator.
11. Design and study of Colpitt/ Hartley oscillator.
12. Design and study of ADC and DAC circuits.
13. Design and study of digital timing circuit using IC555.

PH-407 COMPUTATIONAL PHYSICS LABORATORY

Note: Students are required to perform following experiments using programming language C.

1. Calculate Legendre polynomial of different orders.
2. Calculate Hermite Polynomial of different orders.
3. Calculate and plot Plank's distribution function.
4. Calculate and plot Maxwell's distribution function.
5. Calculate an infinite series up to desired accuracy.
6. Calculate standard deviation of given data.
7. Calculate frequency distribution of given data and plot histogram.
8. Calculate some periodic functions using Fourier Series.
9. Calculate cross sections of some physical processes using given formula.
10. Calculate the wave function of Harmonic oscillator and plot it for one period.
11. Calculate and plot energies and radial wave functions for a square well potential for a few lower l-values.
12. Find product of two square matrices.

Semester II

PH-408 NUMERICAL METHODS

UNIT- 1
Errors in numerical calculations, definition of root or zero of a function, Numerical solution of transcendental equations, concept of iterative methods. Bisection method, False position method, Newton-Raphson method, Secant method, Successive iteration, Comparison of different root methods, Properties of roots of polynomial.

UNIT- 2
Elimination method for solution of simultaneous equations, Gauss elimination, Pivoting, Gauss-Jordan method, Gauss-Seidal, Jacobi method, Solution of Eigen equations, Concept of Eigen system, Polynomial method, Eigen values & Eigen vectors of matrices.

UNIT- 3
Interpolation: Polynomial interpolation, Newton formula for interpolation, Forward differences, Differences of polynomial, Backward differences, Lagrange's interpolation, Divided differences interpolation and inverse interpolation, Finite difference operators, Spline interpolation, Least square curve fitting, Linear regression.

UNIT- 4
Numerical differentiation, First order derivative by a two point formula, Numerical Integration, Trapezoidal rule of integration, Simpson's 1/3 rule, Simpson's 3/8 rule of integration, Double integration, Newton-Cotes formulae of integration, Gaussian integration formula, Gaussian two point formula.

UNIT- 5
Solution of first order ordinary differential equations, Picard method, Taylor series method and Euler's method, Modified Euler's method, Runge-Kutta method, Higher order Runge-Kutta formulas, Predictor-corrector methods , Adams- Moulton Method, Milne's method Finite difference methods, Optimization, Single variable optimization Algorithm.

Books Suggested

E.V. Krishnamurthy and S.K. Sen, Numerical Algorithms, Affiliated East-West Press Pvt. Ltd., New Delhi.
P.B. Patil & U.P. Verma, Numerical computational methods, Narosa Publishing House Pvt. Ltd., New Delhi.

PH-409 ADVANCED QUANTUM MECHANICS

UNIT-1
Scattering (non-relativistic) : Differential and total scattering cross section, transformation from CM frame to Lab frame, solution of scattering problem by the method of partial wave analysis, expansion of a plane wave into a spherical wave and scattering amplitude, the optical theorem, Applications-scattering from a delta potential, square well potential and the hard sphere. Scattering of identical particles, energy dependence an resonance scattering. Breit-Wigner formula, quasi stationary states.

The Lippman-Schwinger equation and the Green's functions approach for scattering problem, Born approximation and its validity for scattering problem, Coulomb scattering problem under first Born approximation in elastic scattering.

UNIT-2

Relativistic Formulation ad Dirac Equation: Attempt for relativistic formulation of quantum theory, The Klein-Gordon equation, Probability density and probability current density, solution for free particle K.G. equation in momentum representation, Interpretation of negative probability density and negative energy solutions.

Dirac equation for a free particle, properties of Dirac matrices and algebra of gamma matrices, non-relativistic correspondence of the Pauli equation (inclusive of electromagnetic interaction). Solution of the free particle Dirac equation, orthogonality and completeness relations for Dirac spinors, interpretation of negative energy solution and hole theory.

UNIT-3

Symmetries of Dirac Equation : Lorentz covariance of Dirac equation, proof of covariance and derivation of Lorentz boost and rotation matrices for Dirac spinors, Projection operators energy and spin, Parity (P), charge conjugation (C), time reversal (T) and CPT operators for Dirac spinors.

UNIT-4

Bilinear covariants, and their transformations, behaviour under Lorentz transformation, P,C,Tand CPT, expectation values of coordinate and velocity involving only positive energy solutions and the associated problems, inclusion of negative energy solution, Zitterbewegung, Klein paradox.

UNIT-5

The Quantum Theory of Radiation: Classical radiation field, transversality condition, Fourier decomposition and radiation oscillators, Quantization of radiation oscillator, creation, annihilation and number operators, photon states, photon as a quantum mechanical excitations of the radiation field, fluctuations and the uncertainty relation, validity of the classical description, matrix element for emission and absorption, spontaneous emission in the dipole approximation, Rayleigh scattering. Thomson scattering and the Raman effect, Radiation damping and Resonance fluorescence.

Books Suggested

Ashok Das and A.C. Milissiones, Quantum mechanics - A Modern Approach, Garden and Breach Science Publishers.

Eugen Merzbacher, Quantum Mechanics, Second Edition, John Wiley and Sons, (1970).

Bjorken and Drell, Relativistic Quantum Mechanics, McGraw Hill, (1964).

J.J. Sakurai, Advanced Quantum Mechanics, John Wiley.

PH-410 CLASSICAL ELECTRODYNAMICS

UNIT-1

Electrostatics: Electric field, Gauss law, Differential form of Gaussian law, Another equation of electrostatics and the scalar potential, Surface distribution of charges and dipoles and discontinuities in the electric field and potential, Poisson and Laplace equation, Green's theorem, Uniqueness of the solution with the Dirichlet or Neumann boundary conditions, Formal solutions of electrostatic boundary value problem with Green's function, electrostatic potential energy and energy density.

UNIT-2

Boundary value problems in electrostatic: Methods of images, Point charge in the presence of a grounded conducting sphere, point charge in the presence of a charged, insulated, conducting sphere, point charge near a conducting sphere at a fixed potential, conducting sphere in a uniform electric field by method of images, conducting sphere with hemispheres at different potentials.

UNIT-3

Magnetostatics: Introduction, Biot-Savart law, Ampere's law in circuital form, differential equations of magnetostatics, magnetic scalar and vector potentials, the divergence of the vector potential, the magnetic field of a distance current loop, a magnetic dipole in a magnetic field, boundary conditions on B and H, method of solving boundary value problems in magnetostatics, uniformly magnetized sphere in an external magnetic field, magnetic circuit, magnetic energy.

UNIT-4

Time varying fields: Maxwell's displacement current, Maxwell's equations, vector and scalar potentials, gauge transformation, Lorentz gauge, Coulomb gauge, Green function for the wave equation, derivation of the equations of macroscopic electromagnetism, Poynting's theorem and conservation of energy and momentum for a system of charged particles and electromagnetic fields.

UNIT-5

Radiation by moving charges: Lienard-Wiechert potentials and fields for a moving point charge, electromagnetic fields of a uniformly moving point charge, total power radiated by an accelerated charge: Larmor's formula and its relativistic generalization, angular distribution of radiation emitted by an accelerated charge.

Books Suggested

J.D. Jackson, Classical Electrodynamics, John Wiley.
L.D. Landu and E.M. Lifshitz, Electrodynamics of continuous media, Pargamon Press.
J.R. Reitz and F.J. Milford, Foundation of Electromagnetic Theory, Addition Wesley.
D.J. Griffith, Introduction to Electrodynamics, PHI.

PH-411 SOLID STATE PHYSICS

UNIT-1

Elastic properties of crystals: Different type of elastic constants, energy density, elastic waves in cubic crystals in different directions.

X-ray crystal analysis: Reciprocal lattice, geometrical structure factor and intensity for SC, BCC, FCC, monatomic diamond and polyatomic crystals. Different techniques as the Laue, the powder and rotating methods.

UNIT-2

Dielectric properties in A.C fields: complex dielectric constant and dielectric losses, Debye equations, dielectric polarization and optical absorption. Long distance order theory of alloy by Bragg and Williams.

Ferroelectric properties: dipole theory, thermodynamics of ferroelectric transitions, second and first order transition, Ferroelectric domains, Piezoelectric and pyroelectric materials and applications.

UNIT-3

Defects in crystals: Point defects, Schottky defects, Frenkel defects, Line defects, colour centres, excitations, Planer defects.

Band theory: Bloch theorem, Bloch function and their eigen values. Tight bonding approximation for SC, BCC and FCC. Nearly free electron model, Wigner Seitz method, construction of the Fermi-surfaces, de. Hass-Von Alfen effect, Cyclotron resonance, magneto resistance and quantum Hall effect.

UNIT-4

Magnetism: Quantum theory of dia and para magnetism, Weiss theory of Ferromagnetism. Heisenberg model and exchange integral, Ferromagnetic domains and Bloch wall, Neel model of anti ferromagnets, thermal excitation of magnons, Magnons in antiferromagnets NMR, conditions of resonance, Bloch equation.NMR experiment and Characteristics of an absorption line.

UNIT-5

Superconductivity: Meissner effect, London equations, Type-1 and Type-2 superconductors thermodynamic properties, cooper pair and derivation of BCS Hamiltonian and BCS results. Superconducting tunnelling, DC and A.C Josephson effect, Super current quantum interference, Fullerenes preparation. Properties and applications. High temperature superconductors and their structure, applications.

Books Suggested

C. Kittle, Introduction to Solid State Physics, Seventh Edition, John Wiley & Sons, Inc., Singapore, New York.

A.J. Dekker, Solid State Physics, Macmillan India Ltd, Delhi.

M.A. Omar, Elementry Solid State Physics, Pearson.

J.P. Mckely, Solid State Physics and Semiconductor Physics, A Harper International Edition, New York.

PH-412 NUCLEAR PHYSICS-I

UNIT-1

Nuclear Models: Independent particle model: Motion in mean potential, energy level according to harmonic oscillator potential and infinite square well potential–effect of spin orbit interaction. Prediction of ground spin, parity of odd–A nuclei and odd-odd nuclei-magnetic moment of odd-A nuclei and quadrupole moment.

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

UNIT-2

Nuclear Decays: Alpha decay: Barrier Penetration theory of alpha decay, Geiger Nuttal law.

Beta decay: Fermi theory of beta decay, Kurie plot, Fermi and Gamow –Teller transitions, allowed and forbidden transitions, electron capture, Parity Violation in beta decay, Inverse beta decay, double beta decay, experimental evidence of parity violation.

UNIT-3

Interaction of gamma rays with matter: Interaction mechanism, photoelectric absorption, Compton scattering and pair production, Gamma ray attenuation, attenuation coefficients, absorber mass thickness, qualitative description of photoelectric, Compton and pair production cross sections.

UNIT-4

Pions– the Yukawa interaction, spin of pions, intrinsic parity- isotopic spin of pions, Pion Nucleon scattering and resonances.

Strange particles associated production–strange quantum number, Gellmann–Nishijima formula.

Weak interactions: Neutral Kaons. Regeneration of the short lived component of neutral Kaons. CP violation. Parity violation in weak interaction, tau theta puzzle. CPT theorem statement only.

The quark model- quark model of particles, elementary idea of charm quantum number.

UNIT-5

Experimental Techniques: Gas filled counters; Scintillation counter; Cherenkov counters; GM Counter. Different type of scintillators - photomultiplier tubes. Linear accelerators; Acceleration of heavy ions. Solid state detectors; Surface barrier detectors.

Books Suggested

B.K. Agarwal, Nuclear Physics Lokbharti Publication Allahabad, (1989).
R.R. Roy and B.P. Nigam, Nuclear Physics, Willey -Easter, (1979).
R.D. Evans, The Atomic Nucleus, Mc Graw Hills, (1955)
H. Enge, Introduction Nuclear Physics, Additon-Wesley, (1970).
W.E. Burcham, Elements of Nuclear Physics, ELBS. Longma. (1988)
B.L. Cohen, Concept of Nuclear Physics, Tata McGraw Hills, (1988).
E. Segre, Nuclei and Particles, Benjamin, (1977).

PH-413 GENERAL PHYSICS & LASER LABORATORY

1. To determine Planck’s constant by photocell (using prism).
2. To determine laser beam parameters.
3. To study magneto optic effect and to determine Verdet constant.
4. To determine Young’s modulus of glass by Cornu’s method.
5. To measure Brewster angle and determine refractive index of given material.
6. To determine Planck’s constant by photocell (using filters).
7. To determine slit width from the study of Fraunhoffer diffraction pattern.
8. To study electro optic effect and to determine Kerr constant of a given material.
9. To determine paramagnetic susceptibility of given material (solution).

10. To study Zeeman effect and to determine the splitting of spectral lines.

PH-414 COMPUTATIONAL PHYSICS LABORATORY II (NUMERICAL METHODS)

Note: Students are required to perform following experiments using programming language C.

1. Using the method of least square fit, find the equation of regression line for the given data. Calculate confidence limit of the regression estimates, and use significance test to check the regression estimates, also calculate correlation coefficients for the regression line.

2. Using Gauss Siedel method finds solution of given set of simultaneous equations.

3. Given the formula for differential cross section for scattering of a particle from a target, Using Gauss Quandrature method of numerical integration calculate total cross section.

4. Using Runge-Kutta second order method find numerical solution of the given first order ordinary differential equation.

5. Using Runge-Kutta fourth order method find numerical solution of the given first order ordinary differential equation.

6. To calculate the roots of an algebraic or transcendental equation by using Newton Raphson Method.

7. To calculate the roots of an algebraic or transcendental equation by using Successive Bisection Method.

8. To calculate the roots of an algebraic or transcendental equation by using False position Method.

9. To calculate the roots of an algebraic or transcendental equation by using Successive substitution Method.

10. Interpolation of data for photoelectric cross section to desired range using the Lagrange's interpolation formula. Also calculate the remainder and error in the interpolation formula.

11. Numerical integration by using Simpson's Rule for the wave function as well as the probability density of the Harmonic Oscillator for the specified range.

12. Using Monte-Carlo method integrate numerically the given function in one variable.

M. Sc. Physics
M. Sc. II Year (2016)
Semester III

PH-501 CONDENSED MATTER PHYSICS

UNIT-1
Synthesis and preparation of materials: Gas to solid synthesis and preparation-
(i) Vapour Deposition (ii) Chemical vapour deposition (iii) Sputtering Liquid to solid synthesis and preparation:
(i) Crystal growth from the melt (ii) Liquid quenching (iii) Crystallization from solution.

UNIT-2
Liquid to solid synthesis and preparation:
(i) Sol-Gel method (ii) Ion exchange and intercalation
Solid to solid synthesis and preparation:
(i) Solid state reaction (ii) High pressure preparation and Synthesis (iii) Glass ceramics

UNIT-3
Electrons in solids and surface states: Interacting electron gas: Hartree and Hartree-Fock approximations, correlation energy, screening, plasma oscillations, Dielectric function of an electron gas in random phase approximation.

UNIT-4
Friedel oscillation, strong - interacting Fermi system. Elementary introduction to Landau's quasi-particle theory of a Fermi liquid. Strongly correlated electron gas. Elementary ideas regarding surface states, metallic surfaces and surface reconstruction.

UNIT-5
Disordered Systems and Imperfection in Crystals: Disorder in condensed matter, substitutional, positional and topographical disorder, short and long range order. Atomic correlation function and structural description of glasses and liquid.
Anderson model for random system and electron localization, mobility edge, qualitative application of the idea to amorphous semiconductors and hopping conduction.

Books Suggested

Elliott, The physics and chemistry of solids, John Wiley and sons, New York.
Mott & Davis, Electronic processes in non crystalline materials, Oxford University press.
Aschroft & Mermin, Solid State Physics, New York.
Thomas, Transmission Electron Microscopy.

PH-502 COMMUNICATION AND MICROWAVE ELECTRONICS

UNIT-1
Amplitude and frequency modulation (mathematical expressions and wave shapes), Transistor collector AM circuit, Square law detector and AGC, Transistor reactance variation frequency modulator circuit, Foster–Seeley discriminator, superhetrodyne receiver, SSB generation circuit, PAM, PWM, PPM, PSK.

UNIT-2
Block diagram of black & white and colour television transmitter and receiver, TV channels, interlace scanning and bandwidth of a channel, TV cameras, Basics of satellite communication, orbital and geostationary satellites and their applications.

UNIT-3
Equivalent circuit of a transmission line and its voltage and current equations, characteristic impedance and propagation constant of a transmission line, impedance properties, reflection coefficient and VSWR; Vector wave equation, rectangular waveguide and field equations for TE mode, Micro-strip lines and their characteristics, optical fibers and its parameters.

UNIT-4
Structure and working of two cavity klystron, reflex klystron and its working, Magnetron, Gunn diode and its characteristics, PIN diode and its use as microwave modulator, Read diode, IMPATT and TRAPATT.

UNIT-5
Microwave components: structures and uses of attenuators, cavity resonators, frequency meter, detector, slotted section, ferrite isolator, circulator, horn antenna; microwave measurements; horn antenna characteristics, VSWR, unknown impedance and complex permittivity.

Books suggested

George Kennedy, Electronic Communication Systems, Tata McGraw Hill
S.P. Sharma, Basic Radio and Television, TMH
H. Taub and D.L. Schilling, Principle of Communication Systems, TMH
H.A. Atwater, Introduction to Microwave Theory, McGraw-Hill.
S.Y. Liao, Microwave Devices and Circuits, PHI
M.L. Sisodia and G.S. Raghvanshi, Basic Microwave Techniques and Laboratory Manual, Wiley
J. Gower, Optical Communication Systems, PHI
B.P. Lathi, Modern Digital and Analog Communication Systems, Oxford University Press
B.R. Vishvakarma, Electromagnetic Fields and Applications, NBC International

PH-503 STATISTICAL PHYSICS

UNIT-1
Partition Function: Canonical partition function, Molecular partition function, Translational partition function, Rotational partition function, Vibrational partition function, Electronic and Nuclear partition function, application of rotational partition function, homonuclear molecules and nuclear spin, application of vibrational partition function to solids, vapour pressure, chemical equilibrium, Real gas.

UNIT-2
Ideal Bose-Einstein Gas: Bose-Einstein distribution, Bose Einstein condensation, Thermodynamic properties of an ideal Bose Einstein gas, Liquid Helium, Two fluid model of liquid helium II, Landau spectrum of phonons and rotons, ^{3}He-^{4}He mixtures, Superfluid phases of ^{3}He.

UNIT-3
Ideal Fermi-Dirac Gas: Fermi-Dirac distribution, Degeneracy, Electrons in metals, Thermionic emission, Magnetic susceptibility of free electrons, White dwarf, Nuclear matter.

UNIT-4
Semiconductor statistics: Statistical equilibrium of free electrons in semiconductors, Non-degenerate case, Impurity semiconductors, Degenerate semiconductors, Occupation of donor levels, Electrostatic properties of p-n junction.

UNIT-5
Non-equilibrium states: Boltzmann transport equation, Particle diffusion, Electrical conductivity, Thermal conductivity, Isothermal Hall effect, Non-equilibrium semiconductors, electron hole recombination, quantum Hall effect.

Books Suggested

B.K. Agarwal & M. Eisner, Statistical Mechanics, Wiley Eastern Limited (1988).
B.B. Laud, Fundamentals of Statistical Mechanics, New Age International Publishers (1998).
R.P. Feynman, Statistical Mechanics, A set of lectures, W.A. Benjamin, Inc (1972).
Huang, Statistical Mechanics
Reif, Fundamentals of Statistical and Thermodynamical Physics, McGraw-Hill, New York (1965).
C. Kittel & H. Kroemer, Thermal Physics, W.H. Freeman, San Fransisco (1980).
F. Mandl, Statistical Physics, Wiley, Chichester, UK (1988).
Reif, Statistical Physics, Berkeley Physics Course Vol. V, McGraw-Hill, New York (1967).

PH-504 ATOMIC AND LASER PHYSICS

UNIT-1
Sommerfeld's Theory and and space quantization: Gross structure of energy spectrum of hydrogen atom. Two degrees of freedom, The radial quantum number, The total energy, General characteristics of sommerfeld's elliptic orbits, space quantization, Larmors theorem , Magnetic moment and the Bohr magneton. Stern Gerlach experiment. Spectroscopic terms and their notation.
Pauli's principle and its mathematical formulation, angular momentum, parity and their selection rules, exchange symmetry of wave functions, electron spin functions and matrices.

UNIT-2
Atoms in external magnetic and electric fields**:** The normal and anamolous Zeeman Effect, Weak fields- Russel Saunders terms and general case, The intensities of lines in weak fields and quadrupole lines, Paschen Back effect and illustrative example.
Stark effect, Linear Stark effect, illustration for hydrogen atom and its series limit. General theory for non-hydrogenic atoms-Helium and Alkali metals.

UNIT-3
X-ray spectra: Salient features of x-ray emission spectra, K, L and M series spectra and their origin, energy level diagram, selection rules, relative intensities of lines, regular and Irregular doublets and doublet laws, Sommerfield screening constants, Gamma sum and permanence rule.

Non-diagram lines: Origin on non-diagram lines, Wentzel, Richtmyer and Coster Kronig theories, Auger effect, origin of low frequency satellites.

UNIT-4
X-ray diffraction: Diffraction from a crystal -the structure factor in terms of indices of reflection. Numerical application of Fourier series, Fourier series in two and three dimensions, The Fourier transform, Convolution, Diffraction by a periodic distribution, The electron density equation.
X-Ray spectrographs: Construction, working and focussing action of (i) Oscillating Plane crystal spectrograph (ii) Bent crystal spectrograph of Cauchois, Johann and Johansson type, Resolving and Dispersive Powers for all the spectrographs, Two crystal X-Ray spectrometer, its dispersive and resolving powers.

UNIT-5
Basic elements of a laser: Threshold condition; Four-level laser system, CW operation of laser; Critical pumping rate; Population inversion and photon number in the cavity around threshold; Output coupling of laser power.
Optical resonators; Cavity modes; Mode selection; Pulsed operation of laser: Q-switching and Mode locking; Experimental technique of Q-switching and mode locking
Different laser systems: Ruby, CO2, Dye and Semiconductor diode laser.

Books Suggested

I.I. Sobel'man, Introduction to the Theory of Atomic Spectra, Pergamon Press.
E.U. Condon and G.H. Shortley, The Theory of Atomic Spectra,Cambridge University Press.
A.H. Compton and S.K. Allison, X-Rays in Theory and Experiment,D Van Nostrand Company, INC
B.K. Agarwal, X-Ray Spectroscopy, Springer Verlag Berlin, Heiderberg, New York.
Raj Kumar, Atomic and Molecular Spectra, Kedarnath Ramnath , Meerut.
Gupta Kumar Sharma, Elements of spectroscopy, Pragati Prakashan (2012)
K. Thyagarajan and A.K.Ghatak, Lasers, Theory and Applications.
O. Svelto, Principles of Laser.

PH-505 NUCLEAR PHYSICS II

UNIT-1
Nuclear Forces and Nuclear Reactions: Nuclear Reactions: Theories of Nuclear Reactions; Partial wave analysis of reaction Cross section; Compound nucleus formation and breakup. single level Breit Wigner formula, the optical model and stripping reactions.

UNIT-2
Deuteron Problem and NP Scattering: Ground state of the deuteron using square well potential, relation between range and depth of potential. Low energy n-p scattering, Scattering length and effective range, scattering by ortho and para hydrogen.

UNIT-3
Interaction of Charge Particles with Matter: Interaction of charged particles with matter: Energy loss of heavy charge particles and stopping power, Range energy relations, Qualitative description of energy loss of electrons passing through matter.

Interaction of neutrons: Slowing down of neutrons in matter, Energy distribution of neutrons after collision.

UNIT-4
Gamma decay: Width of decaying states, selection rules and transition probability for gamma emission. Internal electron conversion, Angular correlation studies, Mössbauer effect, Mössbauer Parameters and Applications of Mössbauer Spectroscopy.

UNIT-5
Nuclear Detectors II: measurement with scintillation detectors-NaI(Tl), plastic scintillator-Scintillation spectrometer, spectrum analysis.
Semiconductor detectors, semiconductor properties- physics of semiconductor detectors-diffused junctions, surface barrier and ion implanted detectors. Si(Li), Ge(Li) and Hp-Ge detectors-semiconductor detector spectrometer. Pulse height analysis of spectrum.

Books Suggested

B.K. Agarwal, Nuclear Physics (Lokbharti Publication Allahabad. 1989).
R.R. Roy and B.P.Nigam, Nuclear Physics (Willey -Easter, 1979).
R.D. Evans, The Atomic Nucleus (Mc Graw Hills, 1955)
H. Enge, Introduction Nuclear Physics (Additon-Wesley, 1970).
W.E. Burcham, Elements of Nuclear Physics (ELBS. Longma. 1988)
B.L. Cohen, Concept of Nuclear Phsyics (Tata McGraw Hills, 1988).
E. Segre, Nuclei and Particles (Benjamin, 1977).

PH-506 COMMUNICATION AND MICROWAVE ELECTRONICS LABORATORY

1. Design and study of amplitude modulation and demodulation circuits.
2. Design and study of frequency modulation and demodulation circuits.
3. Design and study of pulse width/position/amplitude modulation and demodulation circuits.
4. Study of optical fiber parameters.
5. Waveform analysis using storage CRO.
6. Design and study of automatic gain control circuit.
7. Study of reflex klystron characteristics.
8. Study of Gunn diode characteristics and PIN modulator.
9. Determination of unknown impedance by VSWR measurements at microwave frequency.

10. Determination of real part of relative complex permittivity of a solid sample by two point method at microwave frequency.
11. Study of horn antenna characteristics.
12. Measurements of dipolar liquid complex permittivity.
13. Study of micro-strip components characteristics.

PH-507 NUCLEAR AND CONDENSED MATTER LABORATORY

1. To Study Random nature of radioactive decay using GM counter.
2. Energy calibration and resolution of GRS using MCA.
3. Study of Mössbauer spectrum of standard absorbers and calculations of various Mössbauer parameters.
4. Study of dispersion relations of mono and di-atomic basis using Lattice dynamic Kit.
5. Calibration of gamma ray spectrometer and identification of unknown source.
6. Determination of Critical Temperature of a given superconducting material.
7. Study of Hall Effect in Semiconductor (Si/Ge).
8. Study of Electron Spin Resonance in crystals and determination of ‘g’ factor.
9. Determination of Electrical resistivity of semiconductor by four probe method.
10. Determination of Dead time and characteristics of GM Counter.
11. To study spectrum of β- particles using Gamma ray spectrometer.
12. To Determine Critical potential with the help of Franck – Hertz’s Experiment.
13. Determination Half Life Time of a Radio Isotope using GM counter.
14. Study of Quantum Dots and determination of size.
15. Determination of Rydberg constant ‘R’ from Balmer series of Hydrogen Spectrum.
16. Determination of velocity of ultra sound using diffraction technique.

Semester IV

PH-508 ADVANCED CONDENSED MATTER PHYSICS

UNIT-1

Imperfections in Crystals: Mechanism of plastic deformations in solids, stress and strain fields of screw and edge dislocations. Forces between dislocations stress needed to operate Frank - Read source, dislocations in bcc, fcc and hcp lattices.

Experimental methods of observing dislocations and stacking faults, Electron microscopy, Kinematical theory of diffraction contrast and Lattice imaging.

UNIT-2

Film composition Determination, spatial variation of film composition, Film thickness measurement by (a) during evaporation, (b) multiple beam interferometry, (c) using a Hysteresis graph, (d) other methods. Mechanism of film formation.

Film and surfaces: Study of surface topography by multiple beam interferometery. Condition for accurate determination of step height and film thickness (Fizeau Method). Electrical conductivity of thin film and its expression.

UNIT-3

Difference of behavior of thin films from bulk: Boltzmann Transport equation for thin film (for diffuse scattering), thermal conductivity of thin films. Elementary concept of surface crystallography, scanning, tunneling and Atomic force microscopy.

UNIT-4

Reduced Dimensionality: Basic concepts underlying 0D, 1D systems and their applications, Zero dimensional systems - Fullerenes and quantum dots, optical and electronic properties of quantum dots. One dimensional system: one dimensional metals, Peierls distortion, conjugated polymers, nano tubules, quantum wires.

UNIT-5

Two dimensional Systems: Basic concepts of 2D systems and their applications. Layered crystals, Heterojunctions, quantum wells, artificial structures, quantum Hall effect. Applications - semiconductor transistors and opto-electronic devices.

Books Suggested

Elliot, The Physics and chemistry of solids, John Wiley & sons, New York.
Thomas, Transmission Electron Microscopy,
Tolansky, Multiple Beam Interferometery.
Heavens, Thin Films.
Chopra, Physics of Thin Films.
Aschroft & Mermin, Solid State Physics, New York.
Mott & Davis, Electronic Processes in Non crystalline Materials, Oxford Univ. Press.

PH-509 DIGITAL ELECTRONICS AND MICROPROCESSOR

UNIT-1

Digital Logic Circuits: Logic gates and logic families: DTL, TTL, Boolean algebra, development of Boolean expressions: SOP, Minimization techniques: using laws of Boolean algebra, Karnaugh map.

Number Systems and their inter conversion, data representation: fixed-point representation, floating point representation, error detection and correction: parity generator-checker, Hamming codes (1-bit detection-correction).

UNIT-2

Combinational and Sequential logic circuits: binary adder, 4-bit adder-subtractor, flip-flops: RS flip-flop, JK flip-flop, T-flip-flop, D-flip-flop, master-slave JK flip-flop, Registers: controlled buffer register, shift registers, ring counter, Counters: asynchronous counter, synchronous counter, modulus counter.

UNIT-3

Architecture of 8085 microprocessor: register organization, bus organization, ALU and controls, classification of 8085 instructions, addressing modes, fetch and execution of instructions, data transfer: memory-mapped I/O and peripheral mapped I/O, interrupted driven data transfer, programmable interrupt controller, DMA data transfer, DMA controller, assembly language programming.

UNIT-4

Architecture of simple I/O devices: Hex keyboard, LED display, VDU and their interfacing, 8279 keyboard-display interface, CRT controller, Interfacing devices: I/O ports, programmable peripheral interface - 8255 A.

D/A and A/D conversion: Basics of operational amplifier, D/A conversion: R-2R ladder network, DAC 0808, A/D conversion: counter method, successive approximation method, sample and hold circuits. ADC 0801.

UNIT-5

Applications of 8085: Designing of a microcomputer system: Hardware design, software design, Transfer of data between two microcomputers in distributed processing, Temperature monitoring system, data acquisition system: 8085 based temperature monitoring system. Introduction to 16-bit microprocessors: Intel 8086: architecture, addressing modes and instruction set.

Books Suggested

A.P. Malvino, Digital Computer Electronics, Tata McGraw Hill.

A.P. Malvino and D. Leach, Digital Principle and applications, Tata McGraw Hill.

Morris-Mano, Computer System Architecture, PHI.

R.S. Gaonkar, Microprocessor Architecture, Programming and Applications. Wiley Eastern Ltd.

M. Raffiquzzaman, Microprocessor: Theory and Application, Prentice Hall Of India.

Ghosh and Sridhar, Introduction to Microprocessor for Engineers and Scientists, Prentice Hall Of India.

D.V. Hall, Microprocessor and Interfacing, Tata McGraw Hill.

PH-510 ELECTRODYNAMICS AND PLASMA PHYSICS

UNIT-1
Wave Guides and Resonant Cavities: Fields at the surface and within a conductor, Wave guides with perfectly conducting walls, Rectangular Wave guide, cylindrical wave guide. Modes in wave guides: TE, TM and TEM modes, cutoff frequency, energy flow and attenuation in waveguides. Coaxial transmission lines. Resonant cavities.

UNIT-2
Simple radiating systems: Fields and radiation of a localized oscillating source, electric dipole fields and radiations, total power radiated and angular distribution of radiated power, magnetic dipole and electric quadrupole fields, centrefed linear antenna: approximation of sinusoidal current, the antenna as boundary value problem.

UNIT-3
Scattering and diffraction of radiations: Scattering at long wavelength, scattering by dipoles induced in small scatters, scattering by a small dielectric sphere, scattering by a small perfectly conducting sphere, scalar diffraction theory, Kirchhoff's integrals.

UNIT-4
Magnetohydrodynamics and Plasma Physics: Basic properties of plasma, Magnetohydrodynamic equations, Magnetic diffusion, viscosity and pressure. Steady state, pinch effect. Qualitative aspects of instability in a pinched plasma column, High frequency plasma oscillations, short wave length limit of plasma oscillations and Debye screening distance.

UNIT-5
Dynamics of relativistic charged particle: Motion of charged particle in non-uniform static magnetic fields. Adiabatic invariance of flux through the orbit of particle, magnetic mirror. Lagrangian and Hamiltonian for a relativistic charged particle in external electromagnetic fields, covariance of equation of motion, Euler Lagrange equation.

Books Suggested

Jackson, Classical Electrodynamics, John Wiley.
Landu and Lifshitz, Electrodynamics of continuous media, Pargamon Press.
Reitz and Milford, Foundation of Electromagnetic Theory, Addition Wesley.
Griffith, Introduction to Electrodynamics, PHI.

PH-511 MOLECULAR AND RESONANCE SPECTROSCOPY

UNIT-1
Group Theory: Symmetry elements, symmetry operations and point groups, symmetry operations on molecular motions, symmetry species and character tables, nature of a group. Symmetry operations and representation of a group, reducible and irreducible representation, characteristics of irreducible representation, characters of representations, classes, analysis of a reducible representations, the characters for the reducible representation of molecular motion.

UNIT-2

Types of Molecular Energy States And Molecular Spectra :Concept of molecular potential, Separation of electronic and nuclear wave functions, Born-Oppenheimer approximation, Types of spectra, Regions of spectra.

Pure rotational spectra (Microwave or Far Infra Red spectroscopy): Salient features of rotational Spectra, Rotation spectra of Polyatomic molecules, Linear, symmetric top, spherical top and Asymmetric top molecules.

UNIT-3

Vibrational rotational spectra (Near Infra Red spectroscopy): Salient features of Vibrational rotational spectra, Vibrating diatomic molecules as anharmonic oscillator, Vibrational spectra of polyatomic molecules, normal coordinates and and normal modes of vibration

Electronic Spectra of Diatomic Molecules: Salient features of molecular electronic Spectra, Vibrational structure of electronic bands, Deslandres tables, rotational structure of electronic bands, Fortrat Parabola, Combinations relations, electronic states. Frank Condon principle.

UNIT-4

Raman Spectra: Raman effect and its salient features, quantum mechanical explanation of Raman effect, Vibrational Raman Spectra, Pure rotational Raman Spectra, Vibrational-rotation Raman spectra, Raman spectra and molecular structure, Advantages of IR over Raman.

Instrumentation for Raman spectroscopy, Applications; Raman and Fraud.

UNIT-5

Spin Resonance Spectroscopy: Nature of Spinning Particles, Interaction between nuclear spin and magnetic field, Nuclear magnetic resonance, Nuclear quadrupole resonance, Electron spin resonance, Hyperfine structure of E.S.R absorptions.

Reference Books

Kettle, Symmetry and Structure

Claire Vallance, Molecular symmetry, Group theory, & Applications

PH-512 ELECTIVE COURSE / PROJECT

PH-512A GLASSES

Definitions, properties; Structural features: Atomic arrangement, chemical composition; Thermo dynamical features: Glass transition, Thermal stability and structural relaxation; Optical features: Transparency, linear and non-linear refractive index and dispersion, Classification of glasses by preparation method, Glass by melt-quenching technique, Glass by chemical vapor deposition, Glass by sol-gel process.

Important glass systems: oxide glasses. Halide and oxy-halide glasses, chalcogenide glasses Fundamentals of Laser Physics, Stimulated emission cross-section, Creation of population inversion, Active ions for laser glasses, Laser parameters and their host dependence, Bulk laser glasses.

Books Suggested

Masayuki Yamane and Yoshiyuki Asahara, Glasses for photonics.

Von Vlack, Elements of Materials Science.
Resenthal Asimow, Introduction to properties of Materials.

PH-512B FUNDAMENTAL ASTRONOMY

Astronomy fundamentals, Black body radiation, Radiation mechanism, Flux density and luminosity, basics of Radiative transfer and Radiative processes, Magnitudes, Motions and Distances of Stars : Absolute stellar magnitude and distance modulus, Bolometric and radiometric magnitudes, Colour-index and luminosities of stars Stellar positions and motions, Velocity dispersion, Statistical and moving cluster parallax, Extinction, Stellar temperature, Effective temperature, Brightness temperature, Color temperature, Kinetic temperature, Excitation temperature, Ionization temperature, Spectral Classification of stars, Utility of stellar spectrum, stellar atmospheres.

Books Suggested

T. Padmanabhan, Theoretical Astrophysics, Vols.1-3, Cambridge University Press, (2005).
B.W.Carrol & D.A.Ostlie, An Introduction to Modern Astrophysics.
M.Harwit, Astrophysical Concepts.
Baidyanath Basu, An Introduction to Astrophysics.
K.D. Abhayankar, Astronomical Physics: Stars and Galaxies
D.Mihalas, Stellar Atmospheres
S.Chandrasekhar, An Introduction to the Study of Stellar Structures.

PH-512C DIELECTRIC SPECTROSCOPY

Complex permittivity, broadband dielectric spectroscopy, complex conductivity, electric modulus, impedance spectroscopy, complex dielectric function of water, relaxation time, solid polymeric nanocomposite electrolytes, ions conduction mechanism in solid electrolytes, dc ionic conductivity, static permittivity, permittivity at optical frequency, various measurement techniques of solids and liquids complex permittivity and its variation with temperature.

Books Suggested

N.E. Hill, W.E. Vaughan, A.H. Price, M. Davies, Dielectric Properties and Molecular behavior, Van Nostrand Reinhold Co., London
F. Kremer, Broadband Dielectric Spectroscopy, Springer.
J.P. Runt, J.J. Fitzgerald, Dielectric Spectroscopy of Polymeric Materials, ACS.
A.R. Von Hipple, Dielectric Materials and Applications, John Wiley & Sons, Inc., New York.

PH-512D ADVANCED COMPUTATIONAL PHYSICS

Solution of linear systems of equations, inverse of a matrix and the determinant. Cubic- spline interpolation. Outline of the Monte-Carlo strategy, crude integration, particles in a box, radioactive decay, properties of selected random number generators, random walks and the Metropolis algorithm, diffusion equation, random walks. Quantum Monte Carlo methods: Variational Monte Carlo for quantum mechanical systems, The hydrogen atom.

Optimization techniques: exact line search methods, golden section method, Fibonacci method, quadratic and cubic interpolation methods, inexact line search methods, Goldstein rule, gradient descent methods, quasi Newton methods. Neural networks: introduction, different architectures of neural networks, activation functions, training of neural networks, overview of the applications of neural networks in physics

Books Suggested

M. Hjorth-Jensen, Computational Physics, University of Oslo, online library (2003).
E.V. Krishnamurthy and S.K. Sen, Numerical Algorithms, Affiliated East-West Press Pvt. Ltd., New **Delhi.**
L. Fausett, Fundamentals of Neural Networks, Pearson Education Inc. (2012).

PH-512E SOFT X-RAY SPECTROSCOPY

Conventional sources, Basics of high-tension circuits and vacuum systems used for the operation of X-ray tubes. Synchrotron as a source, Synchrotron radiation, Production and properties of radiation from storage rings, Insertion devices. Pelletron as a source of X-rays. Vacuum spectrographs, Lenses and Tangential incidence grating spectrographs. Dispersion and resolving power of spectrographs, detectors, emission spectra, absorption spectra recording, Interpretation of Absorption spectra..

Books Suggested

A. H. Compton and S. K. Allison: X-rays in Theory and Experiment
G. L. Clark: Applied X-rays.
A. G. Michette and C. J. Buckley: X-ray Science and Technology.
M. A. Blokhin: X-ray Spectroscopy.
B. K. Agarwal: X-ray Spectroscopy.
L. V. Azaroff: X-ray Spectroscopy.
C. Bonnelle and C. Mande: Advances in X-ray Spectroscopy.
B. D. Cullity: Elements of X-ray Diffraction.
M. M. Woollfson: X-ray Crystallography.
C. Kunz: Synchrotron Radiation.

PH-512F NONLINEAR DYNAMICS AND CHAOS

Chaotic dynamics, Classical linear and non-linear vibration theory, maps and flows- A mathematical model of biological population growth (Logistic map) and model of convecting fluids (Lorentz model), Determinism unpredictability and divergence of trajectories (Butterfly effect). Identification of chaotic vibration, non-linear system elements, random inputs, time history, phase plane, Fourier spectrum and autocorrelation, Poincare maps and return maps. Bifurcations-route to chaos, quasi-periodicity and mode locking, transient chaos, conservative chaos, Lypunov exponents and fractal dimensions, strange non-chaotic motions.
Geometry of mappings and classification of map dynamics, quasi-periodic and stochastic motion, Impact oscillator maps, Fractal orbits. Local stability of 2D maps, Global dynamics of 2-D maps – linear transformation, folding in 2D maps, composition of maps. Saddle manifolds, tangles and chaos, From 2D to 1D maps-kicked rotor, Circle map, Henon map. Period-doubling root to chaos – qualitative features, poincare maps, bifurcation diagrams, quantitative

measures, Feigenbaum numbers, amplitude and sub-harmonic spectra scaling. Measure of chaos-Lypunov exponents, probability density functions (PDF) and numerical calculation of PDF, PDF and Lyapunov exponents. 3D flows and maps-Lorentz model for fluid convection, Duffing equation and "Japanese attractor", a map from a 4D conservative flow.

Books Suggested

F. C. Moon, Chaotic and fractal dynamics, John Wiley and Sons (1992).
R. C. Hilborn, Chaos and non-linear dynamics, Oxford University Press (2000).
K. Alligwood, T. Sauer and J. A.Yorke, Chaos-An introduction to dynamical systems, Springer Verlag, New York (1997).
E. Ott, Chaos in dynamical systems, Cambridge University Press.
M. C. Gutzwiller, Chaos in classical and quantum mechanics, Springer Verlag, New York (1990).

PH-512G THE GENERAL THEORY OF RELATIVITY

Review of Riemannian geometry: Metric tensor, covariant differentiation, curvature tensor, Bianchi Identities, Ricci tensor.
Motion of a particle in a gravitational field, geodesic. Equations of electrodynamics in the presence of a gravitational field. Gravitational field equations: Action for gravitational field, Energy-momentum tensor, Extremum principle, Einstein field equations, Energy-momentum pseudotensor.
Field of gravitating bodies: Schwarzschild solution, Birkhoff's theorem, Motion in a centrally symmetric gravitational field, Precession of perihelion of Mercury, Deflection of light, Gravitational waves: Plane waves, Weak field approximation, Gravitational radiation.
Cosmological constant: Einstein space, de Sitter space, Anti-de Sitter space.
RelativisticCosmology: Thermal background, Hubble expansion, Big bang, Age and density of the universe. Introduction to Friedmann-Robertson-Walker universe.

Books Suggested

W. Rindler, Relativity---Special, General, and Cosmological, Oxford University Press, New York, (2001).
C. W. Misner, K. S. Thorne, and J. A. Wheeler, Gravitation, Freeman, NewYork, (2000).
L. D. Landau and E. M. Lifshitz, The Classical Theory of Fields, Butterworth Heinmann, (1996).
J. V. Narlikar, Introduction to Cosmology, Cambridge University Press, New Delhi, (1993).
A. Einstein, The Meaning of Relativity, Oxford & IBH, (1990).
P. A. M. Dirac, General Theory of Relativity, Prentice Hall of India, (2001).
W. Pauli, Theory of Relativity, Dover, (1981).
R. P. Feynman, F. B. Moronigo, and W. G. Wagner, Feynman Lectures on Gravitation, Addison-Wesley, (1995).
S. Wienberg, Gravitation and Cosmology, John Wiley, (2004) (Indian Reprinting).
Satya Prakash, Relativistic Mechanics, Pragati Prakashan, Meerut.
James L. Anderson, Principles of Relativity Physics, Academic Press, New York.
C. Moller, The Theory of Relativity, Oxford University Press.

PH-512H QUANTUM OPTICS

Density matrix formulation, Photon statistics, Super Poissonian and Sub Poissonian light, degradation of photon statistics by losses, Photon anti bunching, Hanburry Brown Twiss Experiment and classical intensity fluctuation, second order correlation function, Bunched and anti bunched light, Experimental demonstration of photon anti bunching, Single photon sources.

Coherent states and squeezed states of light, detection and generation of squeezed light.

Atom photon interaction, Rabi Oscillations, Jaynes Cumming Model, introductory ideas about cavity electrodynamics and its applications.

Books Suggested

M. Fox, Quantum Optics- An introduction, Oxford University Press (2006).

S.M. Barnett and P.M. Padmore, Methods of Theoretical Quantum Optics, Clarendon Press, Oxford (2002).

D.F. Walls and G.J. Milburn, Quantum Optics, Springer (1995).

M.O. Scully and M.S. Zubairy, Quantum Optics, Cambridge University Press (1997).

R. Loudon, The Quantum Theory of Light, Clarendon Press, Oxford (1997).

PH-512I RADIATION PHYSICS

Radioactivity, Types of Radioactive Material, Method of Measurement of Radioactivity, Standardization of X ray and Gamma ray beam, Ionization Chamber for low, medium and high energy X ray and Gamma rays, Burlin's theory for Measurement of Radiation Quantity, Radiation Therapy, beam therapy, X ray therapy, Telegamma therapy, Treatment planning in teletherapy, Criteria for Source Selection, Parker Dosage System, Radioactive Shipment for Medical and Industrial Research, Requirement for preparation, forwarding, storage and transport of packages, marking and labeling requirements, limits on non fixed contamination and radiation level, temperature outside packages, transport documents, Emergency Response Requirement, Source of Radioactive waste and classification of waste, Treatment techniques for solid, liquid and gasses, effluents, permissible limit for disposal of waste, sampling technique for air, water and solids, ecological consideration, General method for disposal, management of Radioactive waste in medical and research institution, Evolution of Radiation Hazard in medical diagnostic and therapy institution, protective measure to reduce radiation exposure to staff and patients, Radiation Hazard Laboratories and Particle accelerator facility, protective equipments, handling of patients, radiation safety during source transfer operation, special safety consideration for accelerator installation.

Reference Books

Attix F. H. et al, Radiation Dosimetry Vol. I, II and III, Academic Press NY (1968).

Faiz M. Khan, The Physics of Radiation Therapy

James E Turner, Atoms, Radiation & Radiation Press, Pergamon Press (1986).

Merril Eisenbud, Environmental Radioactivity, Academic Press, Oriando (1978).

PH-513 DIGITAL ELECTRONICS AND MICROPROCESSOR LABORATORY

1. To study Boolean algebraic expressions.
2. To construct and study R-S flip-flop and clocked R-S flip-flop using logic gates.
3. To construct and study J-K flip-flop using logic gates.
4. To construct and study 4 bit buffer register using flip-flop ICs.
5. To construct and study 4 bit shift left and shift right registers using flip-flop ICs and hence convert them into ring counter.
6. To construct and study 4 bit Asynchronous counter using flip-flop ICs.
7. To construct and study 4 bit Synchronous counter using flip-flop ICs.
8. Write an assembly language program to find the sum of a series of 8 bit numbers.
9. Write an assembly language program to find the smallest of the series of 8 bit numbers.
10. Write an assembly language program to find the largest of the series of 8 bit numbers,
11. Write an assembly language program to arrange a series of 8 bit numbers into ascending order.
12. Write an assembly language program to arrange a series of 8 bit numbers into descending order.
13. Write an assembly language program to find the product of two 8-bit numbers.
14. Write an assembly language program to divide an 8-bit number by an 8-bit number.
15. Write an assembly language program to find square root of a perfect/imperfect 8-bit number.
16. Write an assembly language program to find the sum of a series of 16-bit numbers.

PH-514 ATOMIC & MOLECUTAR SPECTROSCOPY LABORATORY

1. K-emission spectrum of Copper using a plane oscillating crystal spectrograph.
2. K-absorption edge of Bromine using a 20 cm curved crystal spectrograph.
3. K-absorption edge of Nickle using a 20 cm curved crystal spectrograph.
4. Laue photograph of muscovite mica crystal.
5. L-emission spectrum of Tungsten using 40 cm/20 cm curved crystal spectrograph.
6. Absorption spectrum of Iodine and calculation of dissociation energy.
7. Spectrum of C-N and determination of vibrational constants.
8. Fine Structure constant using Yellow and Green doublets of Sodium.
9. XRD of standard Silicon and characterization of peaks.
10. Study of glow curve of a crystal using thermo luminescence analyzer.
11. UV-VIS spectrum of a given solution in varying concentration.