PANJAB UNIVERSITY CHANDIGARH- 160 014 (INDIA)

(Estd. under the Panjab University Act VII of 1947-enacted by the Govt. of India)

FACULTY OF SCIENCE

SYLLABI

FOR

M.Sc. (TWO YEAR COURSE) PHYSICS

(Semester System)

EXAMINATIONS 2020-2021

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OUTLINES OF SYLLABI AND COURSES OF READING FOR M.Sc. (TYC) IN PHYSICS (1st to 4th SEMESTER) FOR THE EXAMINATION 2020-21

M.Sc Ist Semester

MAX MARKS (TOTAL = 500)

	Teaching hours per week	Marks	Credits
PHY 8011 Mathematical Physics I	4	15+60 = 75	3
PHY 8012 Classical Mechanics	4	20+80 =100	4
PHY 8013 Quantum Mechanics I	4	20+80 =100	4
PHY 8014 Electronics I	4	15+60 =75	3
PHY 8015 Physics Laboratory I	9	100	4
PHY 8016 Computational Physics I	4	50	2

M.Sc 2nd Semester

MAX MARKS (TOTAL= 500)

	Teaching hours per week	Marks	Credits
PHY 8021 Mathematical Physics II	4	15+60 = 75	3
PHY 8022 Statistical Mechanics	4	20+80 =100	4
PHY 8023 Classical Electrodynamics I	4	20+80 =100	4
PHY 8024 Electronics II	4	15+60 =75	3
PHY 8025 Physics Laboratory II	9	100	4
PHY 8026 Computational Physics II	4	50	2

M.Sc 3rd Semester

	Teaching hours per week	Marks	Credits
PHYS 7001 Classical Electrodynamics II	4	15+60 = 75	3
PHYS 7002 Statistical Mechanics	4	15+60 = 75	3
PHYS 7003 Nuclear Physics II	4	15+60 = 75	3
PHYS 7004 Condensed Matter Physics I	4	15+60 = 75	3
PHYS 7021 Physics Laboratory III	9	150	6
PHYS 7022 Computational Physics I	4	50	2

M.Sc 4th Semester

	Teaching hours per week	Marks	Credits
PHYS 7051 Particle Physics II	4	15+60 =75	3
PHYS 7052 Condensed Matter Physics II	4	15+60 =75	3
PHYS 7071 Physics Laboratory IV	9	125	6
PHYS 7073 Computational Physics II	4	50	2
Special Paper (two of the following)*			
PHYS 7053 Experimental Techniques in Nuclear Physics and Particle Physics	4	15+60 =75	3
PHYS 7054 Fibre Optics and Non-linear Optics	4	15+60 =75	3
PHYS 7055 Nonlinear Dynamics	4	15+60 =75	3
PHYS 7056 Particle Accelerator Physics	4	15+60 =75	3
PHYS 7057 Analytical Techniques for materials	4	15+60 =75	3

Note :

(i) Total number of teaching hours for each of theory papers = 60 hrs.

(ii) All Theory Paper and Practical Exams. will be of 3 hours.

M. Sc. 1ˢᵗ SEMESTER

M. Sc. 1ˢᵗ Semester
PHY8011   **MATHEMATICAL PHYSICS I**

Max. Marks: 15+60 = 75
Teaching hours: 4hrs per week

Objectives: The aim and objective of the course on Mathematical Physics I is to equip the M.Sc student with the mathematical techniques for understanding theoretical treatment in different courses, e.g., to evaluate various definite integrals, to solve various differential equations including Laplace equation, Schroedinger equation, equations used in electronic circuits, electrical circuits, nuclear decays etc., Concepts of Complex analysis, Dirac Delta function, beta, gamma functions, Special functions: Bessel, Legendre, Hermite, Lagurre functions for developing a strong background if the student chooses to pursue research in Physics as a career.

Note:
1. The question paper for the final examination will consist of five units. Unit I-IV will have TWO questions each from the corresponding units of the syllabus. Unit V in the paper will have one compulsory question consisting of 5 to 8 short answer type questions covering the whole syllabus. Each question will have a weightage of 12 marks. The candidates will attempt five questions in all, selecting one each from the units I to IV and the compulsory question from unit V.
2. The question paper is expected to contain problems with a weightage of 30 to 40% of the total marks.

UNIT I

Complex Variables: Introduction, Cauchy Riemann conditions. Cauchy's Integral theorem, Cauchy's Integral formula, Laurent expansion, singularities, calculus of residues, evaluation of definite integrals.Dispersion relation.
(6.1-6.5, 7.1-7.3 of Book1)

UNIT II

Delta and Gamma Functions: Dirac delta function. Delta sequences for one dimensional function, properties of delta function, Orthogonal function and Integral representation of Delta function. Gamma function, Weierstrass form, factorial notation and applications. Beta function. Relation with gamma function.
(8.7, 10.1, 10.4 of Book 1)

UNIT III

Dimensional analysis. Vector algebra and vector calculus. (Book 4)
Linear algebra, matrices, Cayley-Hamilton Theorem. Eigenvalues and eigenvectors.(Book 4)
Differential Equations: Partial differential equations of theoretical physics, separation of variables, singular points, series solutions-Frobenius method, second solution.
(8.1, 8.3-8.6 of Book 1)

UNIT IV

Special Functions: Bessel function of first and second kind, Generating function, integral representation and recurrence relations for Bessel's functions of first kind, orthogonality.

Legendre function: generating function, recurrence relations and special properties, orthogonality. Various Legendre polynomials, Associated Legendre functions: recurrence relations, parity and orthogonality. Hermite functions and Lagurerre function. Generating function, Recurrence relations and orthogonality .

(11.1,11.2,12.1-12.5,13.1,13.2 of Book 1)

TUTORIALS: Relevant problems given at the end of each section in the text books.

Books

1. Mathematical methods for Physicists : G. Arfken and H.J. Weber (Academic Press, SanDiego) (sixth edition) (2005)
2. Matrices and Tensors in Physics: A.W. Joshi (Wiley Eastern, New Delhi) (2002)
3. Mathematical Physics: P.K. Chatopadhyay (Wiley Eastern, New Delhi) (2005)
4. Introduction to Mathematical Physics: C. Harper (Prentice Hall of India, New Delhi) (2004).

M. Sc. 1st Semester
PHY8012   CLASSICAL MECHANICS

Max. Marks: 20+80 = 100
Teaching hours: 4hrs per week

Objectives: The aim and objective of the course on Classical Mechanics is to train the students of M.Sc class in the Lagrangian and Hamiltonian formalism , conservation theorems, rigid body motion, Hamilton's equations , Canonical Transformations to an extent that they can use these in the modern branches like Quantum Mechanics, Quantum field theory, Condensed Matter Physics, Astrophysics etc.

Note:
1. The question paper for the final examination will consist of five units. Unit I-IV will have TWO questions each from the corresponding units of the syllabus. Unit V in the paper will have one compulsory question consisting of 5 to 8 short answer type questions covering the whole syllabus. Each question will have a weightage of 12 marks. The candidates will attempt five questions in all, selecting one each from the units I to IV and the compulsory question from unit V.
2. The question paper is expected to contain problems with a weightage of 30 to 40% of the total marks.

UNIT I

Lagrangian Formulation: Mechanics of a system of particles: constraints of motion. Generalized coordinates, D'Alembert's Principle and Lagrange's velocity – dependent force and the dissipation function. Application of Lagrangian formulation.
(1.1-1.6 of Book 1)

Hamilton Principle : Calculus of variations. Hamilton principle. Lagrange's equation rom Hamilton's principle. Extension to non-holonomic systems, advantages of variational principle formulation, symmetry properties of space and time and conservation theorems.
(2.1-2.6 of Book 1)

UNIT II

Rigid Body Motion : Independent co-ordinates of rigid body, orthogonal transformation.
Eulerian angles and Euler's theorems .infinitesimal rotation. Rate of change of vector, Coriolis force, angular momentum and kinetic energy of a rigid body, the inertia tensor, principal axis transformation. Euler equations of motion. Torque free motion of rigid body, motion of a symmetrical top.
(4.1, 4.2, 4.4, 4.6, 4.8 , 4.9, 4.10, 5.1, 5.3, 5.7 of Book 1)

UNIT III

Small Oscillations: Eigenvalue equation. Free vibrations. Normal Coordinates. Vibrations of a triatomic molecule.
(6.1-6.4 of Book 1)

Hamilton's Equations: Legendre Transformations. Hamilton's equations of motion. Cyclic-co-ordinates. Hamilton's equations from variational principle, principle of least action.
(8.1-8.3, 8.5, 8.6 of Book 1)

UNIT IV

Canonical Transformation and Hamilton- Jacobi Theory: Canonical transformation and its example, Poission brackets. Equations of motion, Angular momentum. Possion's bracket relations, infinitesimal canonical transformation. Conservation Theorems. Hamilton – Jacobi equations for principal and characteristic functions. Harmonic oscillator problem, Action angle variables for system with one degree of freedom.
(9.1, 9.2, 9.4-9.6, 10.1, 10.4, of Book 1)

TUTORIALS: Relevant problems given at the end of each section in the text books.

Books
1. Classical Mechanics: H. Goldstein (Narosa, New Delhi) (1992).
2. Classical Mechanics of Particles and Rigid Bodies: K.C. Gupta (Wiley Eastern, New Delhi) (2006)
3. Analytical Mechanics: L.N. Hand and J.D. Finch (Cambridge University Press, Cambridge) (1998).
4. Classical Mechanics: V.D. Barger and M.G. Olsson, (McGraw-Hill, New York) (1973).
5. Classical Mechanics: N.C. Rana and P.J. Joag (Tata McGraw Hill, New Delhi) (2004)

M. Sc. 1st Semester
PHY 8013   **QUANTUM MECHANICS I**

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Max. Marks: 20+80 = 100
Teaching hours: 4hrs per week

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Objectives: The aim and objective of the course on Quantum Mechanics I is to introduce the students of M.Sc to the formal structure of the subject and to equip them with techniques of linear vector space and matrix mechanics, Stationary state approximate methods, angular momentum , perturbation theory, Variational method with the application to ground states of harmonic oscillator, hydrogen atom etc., Fermi's Golden rule so that they can use these in various branches of Physics as per requirement.

Note:
1. The question paper for the final examination will consist of five units. Unit I-IV will have TWO questions each from the corresponding units of the syllabus. Unit V in the paper will have one compulsory question consisting of 5 to 8 short answer type questions covering the whole syllabus. Each question will have a weightage of 12 marks. The candidates will attempt five questions in all, selecting one each from the units I to IV and the compulsory question from unit V.
2. The question paper is expected to contain problems with a weightage of 30 to 40% of the total marks.

UNIT I

Linear Vector Space and Matrix Mechanics : Vector spaces, Schwarz inequality, Orthonormal basis. Schmidt orthonormalisation method, Operators, projection operator.
Hermitian and Unitary operators, change of basis, Eigenvalue and Eigenvectors of operators. Dirac's bra and ket notation, commutators, Simultaneous eigenvectors.
Postulates of quantum mechanics, uncertainty relation. Harmonic oscillator in matrix mechanics. Time development of states and operators. Heisenberg and Schroedinger representations. Exchange operator and identical particles.
(Ch,1, 2.3, 2.7, 3.9 of Book 1 and 3.16 of Book 2)

UNIT II

Angular Momentum: Angular part of the Schroedinger equation for a spherically symmetric potential, orbital angular momentum operator, Eigen values and eigenvector of L^2 and L_z. Spin angular momentum. General angular momentum, Eigenvalues and eigenvectors of J^2 and J_z. Representation of general momentum operator. Addition of general angular momentum, C.G. coefficients.
(3.8, 3.10, 3.11, 3.12 of Book 1 and 8.1-8.3, 8.5, 8.6, 8.9, of Book 2, Book 5)

UNIT III

Stationary State Approximate Methods: Non- Degenerate and degenerate perturbation theory and its application to anharmonic oscillator, Variational method with application to the ground states of harmonic oscillator, hydrogen atom, helium and other simple cases.
(5.1-5.4, 5.6-58, of Book 2 and Ch 4 of Book 1)

UNIT IV

Time Dependent Perturbation: General expression for the probability of transition from one state to another. Constant and harmonic perturbations. Fermi's golden rule and its application to radiative transition in atoms. Selection rules for emission and absorption of light. (Ch 6 of Book 1 and 9.5-9.8, 9.12- 9.15 of Book 2)

TUTORIALS: Relevant problems given at the end of each section in the text books.

Books :
1. Quantum Mechanics : M.P. Khanna , (HarAnand, New Delhi) (2009).
2. A text book of Quantum Mechanics, P.M. Mathews and K. Venkatesan (Tata McGraw Hill, New Delhi) (2004).
3. Quantum Mechanics: V.K Thankappan (New Age, New Delhi) (2005).
4. Quantum Mechanics: J.L. Powell and B. Crasemann (Narosa, New Delhi) (1998).
5. Modern Quantum Mechanics : J.J. Sakurai (Pearson Education, India) (2009).

M. Sc. 1st Semester
PHY8014   **ELECTRONICS I**

Max. Marks: 15+60 = 75
Teaching hours: 4hrs per week

Objectives: The Electronics I course covers basic circuit analysis, two-port network analysis, analysis of circuits in frequency domain, and basis of various passive filters. It includes physics of various semiconductor devices; Operational amplifier and its applications in analogue computation, comparator circuits, active filters, instrumentation amplifier; IC555 based applications and basics of amplitude and frequency modulation and demodulation.

Note:
1. The question paper for the final examination will consist of five units. Unit I-IV will have TWO questions each from the corresponding units of the syllabus. Unit V in the paper will have one compulsory question consisting of 5 to 8 short answer type questions covering the whole syllabus. Each question will have a weightage of 12 marks. The candidates will attempt five questions in all, selecting one each from the units I to IV and the compulsory question from unit V.
2. The question paper is expected to contain problems with a weightage of 30 to 40% of the total marks.

UNIT I

Semiconductor Devices:
Growth of semiconductor crystals, Direct and indirect semiconductors, Effect of temperature and doping on Carrier concentration and their mobility, Drift and diffusion of carriers, Carrier lifetime and Photoconductivity, Energy band diagrams, position of Fermi level.

Fabrication of p-n junction, Qualitative description of current flow at a junction, Diffusion and depletion capacitance of p-n junctions, Varactors, Ohmic and rectifying contacts, Zener and Avalanche diode, Tunnel diode, Light emitting diode, Laser diode, Photodiodes and Solar cell. Fundamentals of operation of BJT, FET, MOSFET and UJT. Liquid crystal display. High frequency devices: Gunn diode, IMPATT diode.

UNIT II

Circuit Analysis : Thevenin and Norton theorems, Mesh and Node analysis. (Book 3)
Admittance, Impedance, Hybrid and Transmission matrices for two-port networks and their applications (Book 4).

Transforming circuit elements to frequency domain (Laplace transforms), Transfer function, location of poles and stability of circuit, Sinusoidal frequency and phase response (Bode plot), Analysis of LP, HP, BP, BR and AP passive filters. (Book 3)

UNIT III

OPAMP based Circuits: Differential amplifiers, common mode rejection ratio, Transfer characteristics of OPAMP, inverting and noninverting configurations, open loop and close loop gain, Slew rate, Basic internal circuit of IC Opamp.
(Book 5 and 6)

Comparators with hysteresis, Window comparator, Rectangular and triangular wave generators.
555 timer based circuits.
(Book 7)
Analogue computation – Summing amplifier, Integrators and Differentiators, Solving differential equations and simultaneous linear equations, Logarithmic and antilogarithmic amplifiers, Current-to-voltage and Voltage-to-current converters.
(Book 6)
Instrumentation amplifiers. (Book 8)

UNIT IV

Active filters : Sallen-key and Multiquad Configurations for LP, HP, BP filters, Active BR and AP

filters. (Book 9)

Power Devices : pnpn devices, SCR and trigger applications. (Book 1 and Book 2)

Communication systems: General communication system, Generation and detection of amplitude modulated, Single-side band, Double-side band suppressed carrier and Frequency modulated wave. ASK, PSK and FSK, Satellite and mobile communication - TDMA, FDMA, CDMA. (book 10)

TUTORIALS : Relevant problems given in the recommended books.

Books :
1. Solid State Electronic Devices: Ben Streetman, Sanjay Banerjee (Prentice Hall India) 6th Edition (2005).
2. Electronic Devices and Circuits Theory : Boylested and Nashelsky, (Pearson Education) 10th ed. (2009).
3. Circuit theory Fundamentals and Applications : Aram Budak (Prentice-Hall) (1987).

4. Linear and Non-linear Circuits by Chua, Desoer and Kuh (Tata McGraw), (1987).
5. Electronic Fundamentals and Applications, John D. Ryder (PHI, New Delhi) (1983).
6. Integrated Electronics : Millman and Halkias (Tata McGraw Hill) (1991).
7. Electronic Principles : A.P. Malvino (Tata McGraw, New Delhi), 7th edition, (2009).
8. Operational amplifiers and Linear Integrated circuits, R.F. Coughlin and F.F. Driscoll, (Prentice Hall of India, New Delhi) (2000).
9. Applications of Laplace Transforms : Leonard R. Geis (Prentice Hall, New Jersey) (1989).
10. Communication Systems : Simon Haykin, (John Wiley and Sons) (2001).

M. Sc. Ist Semester
PHY8015   **PHYSICS LABORATORY I**

Max. Marks : 100
Teaching hours: 9hrs per week

Objectives: The aim and objective of the courses on Physics Laboratory I and Physics Laboratory II is to expose the students of M.Sc. to the experimental techniques in general Physics, electronics, nuclear Physics and condensed matter Physics so that they can co-relate the theoretical concepts with the experimental ones and develop confidence to handle sophisticated equipments wherever necessary.

Note :
1. All the contents of unit 1 are compulsory. Students are expected to perform at least 10 experiments in each semester from unit 2 taking 5 from each of sections A and B. The experiments performed in first semester cannot be repeated in second Semester.
2. The duration of the examination will be 3 hours.

Unit 1 :

Introduction to experimental techniques : Measurement techniques: Data and error analysis, Plotting and curve fitting software, Introduction to electronic components & use of instruments: Oscilloscope, Multimeter, Wave-form generator.

Unit 2:
Section-A
1. To study the dependence of energy transfer on the mass ratio of the colliding bodies, using air track. OR To verify the law of conservation of linear momentum in collision with initial momentum zero, using air track.
2. To obtain the potential energy curve due to magnet-magnet interactions using air track apparatus.
3. To determine Planck's constant using photocell.
4. To measure heat capacity of solid at high and low temperatures.
5. To determine dielectric constant at high frequency using Leacher Wire. To study reflected waves in Leacher Wire for different terminating loads.
6. To determine dipole moment of an organic molecule, Acetone.
7. To study the characteristic of J-H curve using ferromagnetic standards.

8. To determine the velocity of ultrasonic waves in given liquid, using interferometer.
9. To compressibility of a given liquid by Ultrasonic diffraction grating.
10. Measurement of vacuum using the pirani/thermocouple gauge.
11. To study the characteristics and dead time of a GM Counter.
12. To study Poisson and Gaussian distributions using a GM Counter.
13. To study absorption of beta rays in Al and deduce end-point energy of a beta emitter.
14. Determination of dissociation limit of iodine molecule by constant deviation spectrograph
15. To study the Fresnel's bi-prism and its applications.

Section- B

16. To study temperature-dependence of conductivity of a given semiconductor crystal using four probe method.
17. To determine the Hall coefficient for a given semi-conductor.
18. To study the characteristics of a PN junction with varying temperature and to find the energy band gap of semiconductor. To measure the capacitance of the junction.
19. To study the series and parallel L.C.R. circuit and find its Q factor for different resistances.
20. To study solid state power supply and voltage multiplier circuits (using breadboard).
21. Design different Clipping and Clamping circuits: positive, negative and bias (using breadboard)
22. To study characteristics of (a) Si and Ge diodes, Zener diode and (b) LEDs. solar cell, photodiode and phototransistor.
23. To study dependence of intensity of radiative transitions in LED as a function of temperature and to deduce energy difference between minima of direct and indirect conduction bands of the indirect semiconductor.
24. Hybrid parameters of a transistor and design an amplifier. Determination of k/e ratio.
25. To study Hartley/Colpitts oscillators.
26. To verify the statement: Power dissipation in the side bands in amplitude modulation is directly proportional to the square of the modulation.
27. To study the various aspects of frequency modulation and demodulation.
28. To study the astable and monostable multivibrators.
29. To study logic gates and flip flop circuits.
30. To study common cathode and common anode seven segment display IC's on a bread-board.

M.Sc. Ist SEMESTER
PHYS 8016   COMPUTATIONAL PHYSICS I Lab (Practical Paper)

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Max. Marks: 50
Teaching hours: 4 hrs per week

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Note : The Computational Physics paper will consist of two parts –

(a) Written examination for 40% of the total marks covering Unit I and Unit II with equal weightage and duration one hour. Question paper will be set by the external examiner.

(b) Practical examination for 60% of the total marks and duration two hours.

Unit I

Introduction to Numerical methods: Computer algorithms, interpolations –cubic spline fitting, Numerical differentiation – Lagrange interpolation, Numerical integration by Simpson and Weddle's rules, random generators, Numerical solution of differential equations by Euler, predictor-corrector and Runge-Kutta methods, problems.

Unit II

Computer hardware, software, C++ Programming
Language Algorithms, Structured Programming.

Data and Statements : Data Types. Constants and Variables. Mathematical, Relational, Logical and Bitwise Operators. Expressions and Statements. Block, Local and Global variables. Auto, Static and External Variables.

I/O Statements : printf, scanf, getc, getch, getchar, getche, etc. Streams : cin and cout. Manipulators for Data Formatting: setw, width, endl and setprecision etc. ASCII Files I/O. Preprocessor : #include and #define directives.

Control Statements :- If-statement. If-else Statement. Nested if Structure. Else-if Statement. Ternary Operator. Goto Statement. Switch Statement. Unconditional and Conditional Looping. While Loop. Do-while Loop. For Loop. Break and Continue Statements. Nested Loops.

Arrays and Structures :- One and Two Dimensional Arrays. Idea of Structures.

Unit III

List of Numerical Problems:

1. Data handling: find standard deviation, mean, variance, moments etc. of at least 25 entries.
2. Choose a set of 10 values and find the least squared fitted curve.
3. Generation of waves on superposition like stationary waves and beats.
4. Fourier analysis of square waves.
5. To find the roots of quadratic equations.
6. Wave packet and uncertainty principle.
7. Find first order derivative at given x for a set of 10 values with the help of Lagrange interpolation.
8. To generate random numbers between (i) 1 and 0, (ii) 1 and 100.
9. Perform numerical integration on 1-D function using Simpson and Weddle rules.
10. To find determinant of a matrix - its eigenvalues and eigenvectors.

Books

1. Numerical Mathematical Analysis, J.B. Scarborough (Oxford Book Co.) 4th edition.
2. A first course in Computational Physics: P.L. DeVries (Wiley) 2nd edition 2011.
3. Computer Applications in Physics: S. Chandra (Narosa)2nd edition (2008).
4. Computational Physics: R.C.Verma, P.K. Ahluwalia and K.C. Sharma (New Age) 1st edition (2005).
5. Object Oriented Programming with C++: Balagurusamy, (Tata McGrawHill) 2nd edition (2002).

M. Sc. 2nd SEMESTER

M. Sc. 2nd Semester
PHY 8021   **MATHEMATICAL PHYSICS II**

Max. Marks: 15+60 = 75
Teaching hours: 4hrs per week

Objectives: The aim and objective of the course on Mathematical Physics II is to equip the M.Sc student with the mathematical techniques for understanding theoretical treatment indifferent courses. The knowledge of Fourier analysis, Laplace transforms, tensor analysis, integral equations help to solve plenty of problems in higher Physics. Numerical analysis helps to solve problems of computational physics and develop a strong background if he chooses to pursue research in Physics as a career.

Note:
1. The question paper for the final examination will consist of five units. Unit I-IV will have TWO questions each from the corresponding units of the syllabus. Unit V in the paper will have one compulsory question consisting of 5 to 8 short answer type questions covering the whole syllabus. Each question will have a weightage of 12 marks. The candidates will attempt five questions in all, selecting one each from the units I to IV and the compulsory question from unit V.
2. The question paper is expected to contain problems with a weightage of 30 to 40% of the total marks.

UNIT I

Group Theory: Basic definitions, Multiplication table, conjugate elements and classes. Subgroups, Direct product of groups, Isomorphism and Homomorphism. Permutation groups, Definition of representation and its properties. Reducible and irreducible presentation. Schurs' Lemmas (Statement only), Orthogonal theorem, Characters of a representation. Example of C_{4v}.Topological groups and Lie groups, three dimensional rotation group. Unitary groups: SU(2), O(3), the axial rotation group SO(2). Applications of group theory.
[1.1-1.7, 3.1-3.3, 3.5, 3.6, 4.1-4.3(excluding 4.3.2 and 4.3.3), 4.5 (excluding its subsections)and based on Chapters 5-8 of Book 2]

UNIT II

II Fourier Series and Integral Transforms: Fourier series, General properties, Advantages and applications, Gibbs phenomenon. Development of the Fourier integral, Inversion theorem, Fourier transform, Fourier transforms of derivatives, Momentum representation. Laplace transforms, Laplace transforms of derivatives, Properties of Laplace transform, Faltung theorem, Inverse Laplace transformation.
(14.1-14.5, 15.1-15.6, 15.8-15.10, 15.12 of Book 1)

UNIT III

III Integral Equations: Definitions and classifications, Neumann series, Separable kernels, Hilbert-Schmidt theory. Green's function in one dimension.
(16.1, 16.3, 16.4, 9.5 of Book 1)

IV Tensors: Introduction, definitions, contraction, direct product, Quotient rule. Pseudo tensors, Levi-Civita symbol, irreducible tensors, Non Cartesian tensors - metric tensor. Christoffel symbols, Covariant differentiation.
(2.6-2.10 of Book 1)

UNIT IV

V Elementary Numerical Analysis: Numerical differentiation, Numerical integration by Simpson and Weddle's rules. Numerical solution of differential equations by Euler and Runge-Kutta Method, Linear and non-linear least square fitting, generation of random numbers, Monte-Carlo technique, integration, simulations.
(Books 3 and 4)

Elementary probability theory, random variables, binomial, Poisson and normal distributions. Central limit theorem.
(Book 1)

TUTORIALS: Relevant problems given at the end of each section in the text books.

Books
1. Mathematical methods for Physicists: G. Arfken and H.J. Weber (Academic Press, San Diego) (sixth edition) (2005).
2. Group Theory for Physicists: A.W. Joshi (Wiley Eastern, New Delhi) (2005).
3. Numerical Mathematical Analysis, J.B. Scarborough (Oxford Book Co. Kolkata) (1961).
4. A First Course in Computational Physics: P.L. Devries (Wiley, New York) (1994).
5. Matrices and Tensors in Physics : A.W. Joshi (Wiley Eastern, New Delhi) (2002).
6. Mathematical Physics : P.K. Chatopadhyay (Wiley Eastern, New Delhi) (2005).
7. Introduction to Mathematical Physics: C. Harper (Prentice Hall of India, New Delhi) (2004).

M. Sc. 2nd SEMESTER
PHY 8022   **STATISTICAL MECHANICS**

Max. Marks: 20+80 = 100
Teaching hours: 4hrs per week

Objectives:
The aim of the course is to familiarize the students with the techniques of ensemble theory and relate the statistics and thermodynamics, Gibbs paradox, micro canonical ensemble theory and its application to ideal gas of monatomic particles, equipartition and virial theorems, physical significance of various statistical quantities, energy fluctuations, a system of harmonic oscillators as canonical ensemble, statistics of paramagnetism, thermodynamics of magnetic systems and negative temperatures, significance of statistical quantities, Ising model and Heisenberg models, Fluctuations so that he/she can use these to understand the macroscopic properties of the matter in bulk in terms of its microscopic constituents.

Note :
1. The question paper for the final examination will consist of five units. Unit I-IV will have TWO questions each from the corresponding units of the syllabus. Unit V in the paper will have one compulsory question consisting of 5 to 8 short answer type questions covering the whole syllabus. Each question will have a weightage of 12 marks. The candidates will attempt five questions in all, selecting one each from the units I to IV and the compulsory question from unit V.
2. The question paper is expected to contain problems with a weightage of 30 to 40% of the total marks.

UNIT I

The Statistical Basis of Thermodynamics : The macroscopic and microscopic states, contact between statistics and thermodynamics, classical ideal gas, Gibbs paradox and its solution.
(1.1-1.6 of Book 1).

Elements of Ensemble Theory : Phase space and Liouville's Theorem, The micro canonical ensemble theory and its application to ideal gas of monatomic particles, equipartition and virial theorems, canonical ensemble and its thermodynamics, partition function, classical ideal gas in canonical ensemble theory, energy fluctuations.
(2.1-2.4, 3.1-3.7 of Book 1)

UNIT II

The grand canonical ensemble : Equilibrium between a system and a particle-energy reservoir and significance of statistical quantities. Classical ideal gas in grand canonical ensemble theory. Density and energy fluctuations.
(4.1-4.5 of Book 1).

Elements of Quantum Statistics : Quantum states and phase space, quantum statistics of various ensembles. An ideal gas in quantum mechanical ensembles, statistics of occupation numbers.
(2.5, 6.1- 6.3 of Book 1)

UNIT III

Ideal Bose Systems : Basic concepts and thermodynamic behaviour of an ideal Bose gas, Bose-Einstein condensation, Discussion of gas of photons (the radiation fields) and phonons (TheDebye field).
(7.1- 7.3 of Book 2).

Ideal Fermi Systems : Thermodynamic behaviour of an ideal fermi gas, discussion of heat capacity of a free-electron gas at low temperatures, Pauli paramagnetism [8.1, 8.2A, 8.3 (omit sub sections A and B)].

UNIT IV

Elements of Phase Transitions: First- and second-order phase transitions (Introduction), Diamagnetism, paramagnetism, and ferromagnetism. a dynamical model of phase transitions, Ising and Heisenberg models.
(11.3 of Book 1)

Fluctuations: Thermodynamic Fluctuations, random walk and Brownian motion, introduction to non-equilibrium processes, diffusion equation
(14.1-14.3 of Book 1)

TUTORIALS : Relevant problems given in the end of each chapter in the text book.

Books
1. Statistical Mechanics : R.K. Pathria (Butterworth-Heinemann, Oxford) 2nd edition (2005).
2. Statistical Mechanics : K. Huang (Wiley Eastern, New Delhi) 2011.
3. Statistical Mechanics : B.K. Agarwal and M. Eisner (Wiley Eastern, New Delhi) (1988).
4. Elementary Statistical Physics : C. Kittel (Wiley, New York) (1958).
5. Statistical Mechanics : S.K. Sinha (Tata McGraw Hill, New Delhi) (1990).

M. Sc. 2nd Semester
PHY 8023   **CLASSICAL ELECTRODYNAMICS I**

Max. Marks: 20+80 = 100
Teaching hours: 4hrs per week

Objectives: The Classical Electrodynamics course covers Electrostatics and Magnetostatics, Multipole expansion, concepts of dielectrics: Molecular polarizability, Clasusius Mossetti equation, boundary value problems: Green's theorem, Method of images, Maxwell equations and their applications to propagation of electromagnetic waves in dielectrics, metals and plasma media, EM waves in bounded media: Fresnel amplitude relations, polarization, Total internal reflection, wave guides, radiation from localized time varying sources.

Note:
1. The question paper for the final examination will consist of five units. Unit I-IV will have TWO questions each from the corresponding units of the syllabus. Unit V in the paper will have one compulsory question consisting of 5 to 8 short answer type questions covering the whole syllabus. Each question will have a weightage of 12 marks. The candidates will attempt five questions in all, selecting one each from the units I to IV and the compulsory question from unit V.

2. The question paper is expected to contain problems with a weightage of 30 to 40% of the total marks.

UNIT I

Electrostatics in Vacuum : Coulomb's Law, Gauss Law, Scalar potential. Laplace and Poisson's equations. Electrostatic potentials, energy and energy density of the electromagnetic field.
(1.1-1.4 and 1.6 of Book 1 and 1.1-1.7 of Book 2)

Multipole Expansion : Multipole expansion of the scalar potential of a charge distribution.
Dipole moment, quadrupole moment. Multipole expansion pf the energy of a charge distributionin an external field.
(1.5, 1.7 of Book 1 : 4.1-4.2 of Book 2)

Magnetostatics: the differential equations of magnetostatics, Vector potential. Magnetic field of a localized current distribution.
(3.1-3.5 of Book 1 , 5.1 – 5.7 of Book 2)

UNIT II

Electrostatics of Dielectrics : Static fields in material media. Polarization vector macroscopic equations. Molecular polarizability and electric susceptibility. Clasusius-Mossetti relations. Models of Molecular Polarizability. Energy of charges in dielectric media.
(2.1-2.5 of Book 1 : 4.3, 4.5-4.7 of Book 2)

Boundary value Problems : Uniqueness Theorem. Dirichlet and Neumann Boundary conditions, Green's Theorem, Formal solution of Electrostatic Boundary value problem with Green function. Method of images with examples. Magnetostatic Boundary value problems.
(4.1-4.3 of Book 1: 1.8-1.10, 2.1-2.7, 3.12, 5.9-5.12 of Book 2)

UNIT III

Time Varying Fields and Maxwell Equations : Faraday's Law of induction. Displacement current. Maxwell equations. Scalar and vector potentials. Gauge transformation, Lorentz and Coulomb gauges, General Expression for the electromagnetic fields energy, conservation of energy, Poynting's Theorem. Conservation of momentum.
(5.1-5.5 of Book 1: 6.1-6.5, 6.8-6.9 of Book 2)

EM waves in various unbounded media: Wave equation, plane waves in free space and isotropic dielectrics, polarization, energy transmitted by a plane wave, Poynting's theorem for a complex vector field. Waves in conducting media, skin depth, EM waves in rare field plasma and their propagation in ionosphere.
(6.1-6.8 of Book 1; 7.1-7.5, 7.7 of book 2)

UNIT IV

EM waves in bounded media-Applications : Reflection and Refraction of EM waves at plane dielectrics interface, Fresnel's amplitude relations. Reflection and transmission coefficients. Polarization by reflection. Brewster's angle, Total internal reflection, Parallel plate transmission lines, Wave guides, TE and TM waves, Rectangular wave guides and cavity resonators. **(** 7.1-7.3 of Book 1 ; 8.1-8.8 of Book 2, 9.1, 9.2 of book 4)

Radiation from Localized Time Varying Sources: Solutions of the inhomogeneous wave equation in the absence of boundaries. Fields and Radiation of a localized oscillating source. Electric dipole and electric quadrupole fields, centre fed linear antenna.
(8.1-8.6 of Book 1: 9.1-9.4 of Book 2)

TUTORIALS: Relevant problems given at the end of each section in the text
books. Books
1. Classical Electrodynamics : S.P. Puri, (Tata McGraw Hill, New Delhi) (2nd edition)1997, Alpha Science International Ltd., India (2011).
2. Classical Electrodynamics : J.D. Jackson, (Wiley Eastern, New Delhi) (1998).
3. Introduction to Electrodynamics: D.J. Griffiths, (Prentice Hall India, New Delhi) (2008).
4. Electromagnetic Field Theory Fundamentals: Bhag Singh Guru and H.R. Hiziroglu (Cambridge University Press) 2nd edition, (2004).

M. Sc. 2nd Semester
PHY 8024   **ELECTRONICS-II**

                                   Max. Marks: 15+60=75
                                   Teaching hours: 4hrs per week

Objectives: The Electronics II covers the logic systems : concepts of dc positive, negative systems, logic gates in DL, RTL, DTL and TTL logic families, number systems, Karnaugh map representation of logic functions, Multiplexers and Flip Flops, Registers , Analog to digital converters, digital to analog converters, Semiconductor memory devices : Organizations, operations, classification and characteristics of memories, digital display, Seven segment display, charged couple device memory and applications , Fundamentals, types and various concepts of Microprocessors

Note:
1. The question paper for the final examination will consist of five units. Unit I-IV will have TWO questions each from the corresponding units of the syllabus. Unit V in the paper will have one compulsory question consisting of 5 to 8 short answer type questions covering the whole syllabus. Each question will have a weightage of 12 marks. The candidates will attempt five questions in all, selecting one each from the units I to IV and the compulsory question from unit V.
2. The question paper is expected to contain problems with a weightage of 30 to 40% of the total marks.

UNIT I

Digital circuits : Boolean algebra, de Morgans theorem, Karnaugh maps.
Data processing circuits : Multiplexers, Demultiplexers, Arithmetic building blocks, Encoders, Decoders, Parity generators, PLA.

Digital logic families : RTL, DTL, TTL, ECL, CMOS, MOS, Tri-state logic - switching and propagation delay, fan out and fan in, TTL-CMOS and CMOS-TTL interfaces. (Book 1 and Book 2)

UNIT II

Sequential circuits : Flip-Flops – RS, JK, T, D; clocked, preset and clear operation, race-around conditions in JK Flip-flops, master-slave JK flip-flops, Switch contact bounce circuit.
Shift registers, Asynchronous and Synchronous counters (up, down, up-down, decade), Counter design and applications.
(Book 1 and Book 2)

UNIT III

A/D Converters : Successive approximation, Counter-type, Dual slope, voltage to frequency and voltage to time conversion techniques, accuracy and resolution. Sample-and-hold circuit. D/A converter using resistive network, accuracy and resolution. (Book 1 and Book 2)

Semiconductor memory devices: Organizations, operations, Classification and characteristics of memories, read only memory (ROM organization, PROM, EEPROM), RAM (Bipolar RAM, MOS RAM), Static and Dynamic Random Access Memories, Charged Couple Device Memory, Applications

UNIT IV

Microprocessor : Fundamentals of Microprocessors, Buffer registers, Bus oraganised computers, SAP-I, Microprocessor (μP) 8085 Architecture, memory interfacing, interfacing I/O devices. Instruction classification, addressing modes, timing diagram, Data transfer, Logic and Branch operations.
Microcontroller : Overview of the 8051 family and Architecture.
(Book 4 and Book 5)
IC Fabrication: Basic ideas of integrated circuits, Epitaxial growth, Diffusion, Masking,
Etching, Fabrication of Monolithic Integrated circuits. (Book 6)

TUTORIALS : Relevant problems given at the end of each chapter in the books listed below.

Books :

1. Digital Principles and Applications : Malvino and Leach (Tata McGraw Hill) (2010).
2. Modern Digital electronics, R. P. Jain (Tata McGraw-Hill, New Delhi) (2006).
3. Digital Computer Electronics : Albert P. Malvino, Jerald A Brown (Tata-McGraw Hill) 3rd ed.
4. Microprocessor Architecture, Programming and Applications with 8085 : R.S.
   Gaonkar (Prentice Hall) (2002).
5. The 8051 Microcontroller and embedded Systems by M. Ali Mazidi, J.G. Mazidi and R.D.M.
   Mckinley (Pearson Education) (2009).
6. Integrated Electronics, J. Millman and C.C. Halkias (Tata McGraw-Hill, New Delhi) (2008)

M. Sc. 2nd Semester
PHY 8025   **PHYSICS LABORATORY II**

Max. Marks: 100
Teaching hours: 9 hrs per week

Objectives: The aim and objective of the courses on Physics Laboratory I and Physics Laboratory II is to expose the students of M.Sc. to the experimental techniques in general Physics, electronics, nuclear Physics and condensed matter Physics so that they can co-relate the theoretical concepts with the experimental ones and develop confidence to handle sophisticated equipments wherever necessary.

Note :
1. All the contents of unit 1 are compulsory. Students are expected to perform at least 10 experiments in each semester from unit 2 taking 5 from each of sections A and B. The experiments performed in first semester cannot be repeated in second Semester.
2. The duration of the examination will be 3 hours.

Unit 1 :

Introduction to experimental techniques : Measurement techniques: Data and error analysis, Plotting and curve fitting software, Introduction to electronic components & use of instruments: Oscilloscope, Multimeter, Wave-form generator.
Unit 2:

Section-A
1. To study the dependence of energy transfer on the mass ratio of the colliding bodies, using air track. OR To verify the law of conservation of linear momentum in collision with initial momentum zero, using air track.
2. To obtain the potential energy curve due to magnet-magnet interactions using air track apparatus.
3. To determine Planck's constant using photocell.
4. To measure heat capacity of solid at high and low temperatures.
5. To determine dielectric constant at high frequency using Leacher Wire. To study reflected waves in Leacher Wire for different terminating loads.
6. To determine dipole moment of an organic molecule, Acetone.
7. To study the characteristic of J-H curve using ferromagnetic standards.
8. To determine the velocity of ultrasonic waves in given liquid, using interferometer.
9. To compressibility of a given liquid by Ultrasonic diffraction grating.
10. Measurement of vacuum using the Pirani/thermocouple gauge.
11. To study the characteristics and dead time of a GM Counter.
12. To study Poisson and Gaussian distributions using a GM Counter.
13. To study absorption of beta rays in Al and deduce end-point energy of a beta emitter.
14. Determination of dissociation limit of iodine molecule by constant deviation spectrograph
15. To study the Fresnel's bi-prism and its applications.

Section- B

16. To study temperature-dependence of conductivity of a given semiconductor crystal using four probe method.
17. To determine the Hall coefficient for a given semi-conductor.
18. To study the characteristics of a PN junction with varying temperature and to find the energy band gap of semiconductor. To measure the capacitance of the junction.
19. To study the series and parallel L.C.R. circuit and find its Q factor for different resistances.
20. To study solid state power supply and voltage multiplier circuits (using breadboard).
21. Design different Clipping and Clamping circuits: positive, negative and bias (using breadboard)
22. To study characteristics of (a) Si and Ge diodes, Zener diode and (b) LEDs. solar cell, photodiode and phototransistor.
23. To study dependence of intensity of radiative transitions in LED as a function of temperature and to deduce energy difference between minima of direct and indirect conduction bands of the indirect semiconductor.
24. Hybrid parameters of a transistor and design an amplifier. Determination of k/e ratio.
25. To study Hartley/Colpitts oscillators.
26. To verify the statement: Power dissipation in the side bands in amplitude modulation is directly proportional to the square of the modulation.
27. To study the various aspects of frequency modulation and demodulation.
28. To study the astable and monostable multivibrators.
29. To study logic gates and flip flop circuits.
30. To study common cathode and common anode seven segment display IC's on a bread-board.

M. Sc. 2nd Semester
PHYS 8026   **COMPUTATIONAL PHYSICS II**

Max. Marks: 50
Teaching hours: 4 hrs per week

Note : The Computational Physics paper will consist of two parts –

(a) Written examination for 30% of the total marks covering Unit I and duration one hour. Question paper will be set by the external examiner.
(b) Practical examination for 70% of the total marks and duration two hours.

Unit I

C++ Programming Language
Functions :- Standard Library Functions and User-defined Functions. Void Functions and Functions returning Values. Function Prototypes. Function Call by Value and by Reference. Recursion. Idea of Function Overloading.
Idea of Classes, Objects and Inheritance :- Classes and Objects. Member Functions in a class. Private and Public Qualifiers and Data Security. Constructors and Destructors. Inheritance.
Idea of Strings and Pointers.

Unit II

List of Physics Problems.

Note: Do at least 10 problems using C^{++} programming.

1. Study the charging and discharging of a capacitor in RC circuit with a DC source using Eulermethod. Graphically demonstrate the variation of charge with time for two values of time step size. Modify the program to include AC source instead of D.C. Source.
2. Study the growth and decay of current in RL circuit containing (a) DC source and (b) AC source using Runge Kutta method. Draw graphs between current and time in each case. Perform power analysis in the circuit for two values of time step size for the case.
3. Write a program to study graphically the EM oscillations in a LCR Circuit (use Runge-Kutta method). Show the variations of (a) charge vs time, (b) current vs time.
4. Study graphically the motion of a falling spherical body under various effects of the medium (viscous drag, buoyancy and air drag) using Euler method.
5. Study graphically the path of a projectile with and without air drag, using FN method. Find the horizontal range and maximum height in either case. Write your comments on the findings.
6. Motion of artificial satellite.
7. Study of motion of a one-dimensional harmonic-oscillator without and with damping effect (use Euler method). Draw graphs showing the relations (a) velocity vs time (b) acceleration vs time (c) position vs time.
8. Obtain the energy eigen values of a quantum oscillator using Runge-Kutta method.
9. Study the motion of a charged particle in (a) uniform electric field (b) in uniform magnetic field (c) in combined electric and magnetic fields (cyclotron). Draw graphs in each case.

10. Monte-Carlo technique to simulate phenomenon of Nuclear radioactivity. Modify your program to a case when daughter nucleus is also unstable.
11. Study the motion of two coupled harmonic oscillators. Compare the numerical results with analytic results.

Books

1. Numerical Mathematical Analysis, J.B. Scarborough (Oxford Book Co.) 5th edition, (1964).
2. A first course in Computational Physics: P.L. DeVries (Wiley) (1994).
3. Computer Applications in Physics: S. Chandra (Narosa) 2nd edition, (2008).
4. Computational Physics: R.C. Verma, P.K. Ahluwalia and K.C. Sharma (New Age) 1st edition (1999).

M.Sc. 3rd SEMESTER

M.Sc. 3rd SEMESTER
PHY7001 Classical Electrodynamics II

Max. Marks: 15+60 = 75
Total teaching hours : 60

Objectives:
The course of classical electrodynamics includes the postulates of special theory of relativity, Lorentz transformations, motion of particle in various aspects of electric and magnetic fields like constant and varying fields including non-relativistic and relativistic motions of charge particle and magnetic mirroring. The Covariant Formulation of Electrodynamics in Vacuum gives information of Four vectors in Electrodynamics, covariant continuity equation, wave equation, covariance of Maxwell equations. Electromagnetic field tensor, Energy momentum tensor of the EM fields and the conservation laws. Lagrangian and Hamiltonian of a charged particle in an EM

field. The aim of the course is to take a glimpse of radiation from accelerated charges, Thomson scattering, Rayleigh scattering, absorption of radiation by bound electron.

Note :
1.   The question paper for the final examination will consist of five units. Unit I-IV will have TWO questions each from the corresponding units of the syllabus. Unit V in the paper will have one compulsory question consisting of 5 to 8 short answer type questions covering the whole syllabus. Each question will have a weightage of 12marks. The candidates will attempt five questions in all, selecting one each from the units I to IV and the compulsory question from unit V.
2.   The question paper is expected to contain problems with a weightage of 30 to 40% of the total marks.

UNIT I

Special Theory of Relativity : Postulates of Special theory of Relativity, Interval, Lorentz transformation as orthogonal transformation in 4-dimension,Four velocity and Four acceleration, relativistic equation of motion: Minkowski force, Four momentum, applications of energy momentum conservation : Disintegration of a particle, C.M. System and reaction thresholds.
(9.1-9.6 of Book 1; 11.3-11.7, 11.9-11.10 of Book 2).

UNIT II

Charged Particle Dynamics : Non-relativistic motion in uniform constant fields: Constant uniform electric field, Constant uniform magnetic field, Crossed uniform and constant electric and magnetic fields. Non-relativistic motion of a charged particle in a slowly varying magnetic field : Time varying magnetic field, Space varying magnetic field, Gradient Drift, Curvature Drift. Adiabatic magnetic field invariance of flux through an orbit, magnetic mirroring, Relativistic motion of a charged particle: Constant magnetic field, Constant electric field Electromagnetic Field of a plane wave.
(10.1-10.4 of Book 1).

UNIT III

Covariant Formulation of Electrodynamics in Vacuum : Four vectors in Electrodynamics, 4 current density, 4-potential, covariant continuity equation, wave equation, covariance of Maxwell equations. Electromagnetic field tensor, transformation of EM fields.
Invariants of the EM fields. Energy momentum tensor of the EM fields and the conservation laws. Lagrangian and Hamiltonian of a charged particle in an EM field.
(11.1-11.4, 11.6-11.7 of Book 1; 12.1, 12.3-12.6 of Book 2).

UNIT IV

Radiation From Accelerated Charges : Lienard-Wiechert Potentials, Field of a charge in arbitrary motion and uniform motion, Radiated power from an accelerated charge at low velocities- Larmour-Power formula. Radiation from a charged particle with collinear velocity and acceleration. Radiation from a charged particle in a circular orbit, Radiation from an ultra-relativistic particle, Radiation reaction. Line-width and level shift of an oscillator.
(12.1-12.6, 13.1 and 13.2 of Book 1; 14.1-14.5 of Book 2).

Scattering : Thomson scattering, Rayleigh scattering, absorption of radiation by bound electron.
(14.1-14.3 of Book 1).

TUTORIALS : Relevant problems given in each chapter in the text and reference books.

Books
(a) Classical Electrodynamics : S.P. Puri, (Tata McGraw Hill, New Delhi) 2nd edition (1990).
(b) Classical Electrodynamics : J.D. Jackson, (Wiley Eastern, New Delhi) 3rd edition (1998).
(c) Classical Electromagnetic Radiation : J.B. Marion and M.A. Heald, Academic Press, San Diego) 1st edition (1965).
(d) Introduction to Electrodynamics: D.J. Griffiths, (Prentice Hall India, New Delhi)3rd edition (2008).
5. Classical electrodynamics by S.P.Puri (Narosa Publication, New Delhi) (2011).

M.Sc.-3rdSEMESTER
PHY7002   **STATISTICAL MECHANICS**

Max. Marks: 15+60 = 75
Total teaching hours : 60

Objectives:

The aim of the course is to familiarize the students with the techniques of ensemble theory and relate the statistics and thermodynamics, Gibbs paradox, micro canonical ensemble theory and its application to ideal gas of monatomic particles, equipartition and virial theorems, physical significance of various statistical quantities, energy fluctuations, a system of harmonic oscillators as canonical ensemble, statistics of paramagnetism, thermodynamics of magnetic systems and negative temperatures, significance of statistical quantities, Ising model and Heisenberg models, Fluctuations so that he/she can use these to understand the macroscopic properties of the matter in bulk in terms of its microscopic constituents.

Note :

1. The question paper for the final examination will consist of five units. Unit I-IV will have TWO questions each from the corresponding units of the syllabus. Unit V in the paper will have one compulsory question consisting of 5 to 8 short answer type questions covering the whole syllabus. Each question will have a weightage of 12 marks. The candidates will attempt five questions in all, selecting one each from the units I to IV and the compulsory question from unit V.

2. The question paper is expected to contain problems with a weightage of 30 to 40% of the total marks.

UNIT I

The Statistical Basis of Thermodynamics : The macroscopic and microscopic states, contact between statistics and thermodynamics, classical ideal gas, Gibbs paradox and its solution.
(1.1-1.6 of Book 1).

Elements of Ensemble Theory : Phase space and Liouville's Theorem, The micro canonical ensemble theory and its application to ideal gas of monatomic particles, equipartition and virial theorems, canonical ensemble and its thermodynamics, partition function, classical ideal gas in canonical ensemble theory, energy fluctuations.
(2.1-2.4, 3.1-3.7 of Book 1)

UNIT II

The grand canonical ensemble : Equilibrium between a system and a particle-energy reservoir and significance of statistical quantities. Classical ideal gas in grand canonical ensemble theory. Density and energy fluctuations.
(4.1-4.5 of Book 1).

Elements of Quantum Statistics : Quantum states and phase space, quantum statistics of various ensembles. An ideal gas in quantum mechanical ensembles, statistics of occupation numbers.
(2.5, 6.1- 6.3 of Book 1)

UNIT III

Ideal Bose Systems : Basic concepts and thermodynamic behaviour of an ideal Bose gas, Bose-Einstein condensation, Discussion of gas of photons (the radiation fields) and phonons (TheDebye field).
(7.1- 7.3 of Book 2).

Ideal Fermi Systems : Thermodynamic behaviour of an ideal fermi gas, discussion of heat capacity of a free-electron gas at low temperatures, Pauli paramagnetism [8.1, 8.2A, 8.3 (omit sub sections A and B)].

UNIT IV

Elements of Phase Transitions: First- and second-order phase transitions (Introduction), Diamagnetism, paramagnetism, and ferromagnetism. a dynamical model of phase transitions, Ising and Heisenberg models.
(11.3 of Book 1)

Fluctuations: Thermodynamic Fluctuations, random walk and Brownian motion, introduction to non-equilibrium processes, diffusion equation
(14.1-14.3 of Book 1)

TUTORIALS : Relevant problems given in the end of each chapter in the text book.

BOOKS
1.   Statistical Mechanics : R.K. Pathria (Butterworth-Heinemann, Oxford) 2nd edition (2005).
2.   Statistical Mechanics : K. Huang (Wiley Eastern, New Delhi) 2011.
3.   Statistical Mechanics : B.K. Agarwal and M. Eisner (Wiley Eastern, New Delhi) (1988).
4.   Elementary Statistical Physics : C. Kittel (Wiley, New York) (1958).
5.   Statistical Mechanics : S.K. Sinha (Tata McGraw Hill, New Delhi) (1990).

M.Sc.-3ʳᵈSEMESTER
PHY 7003   **NUCLEAR PHYSICS II**

                                                                    Max.Marks:15+60=75
                                                                    Total teaching hours: 60

Objectives:

The aim and objectives of the course on Nuclear Physics-II is to expose the students of M.Sc. class to the relatively advanced topics in nuclear models and nuclear reactions so that they understand the details of the underlying aspects and it can prepare them to use all these techniques if they decide to become a nuclear physicists in their career.

Note:

1. The question paper for the final examination will consist of five units. Unit I-IV will have TWO questions each from the corresponding units of the syllabus. Unit V in the paper will have one compulsory question consisting of 5 to 8 short answer type questions covering the whole syllabus. Each question will have a weightage of 12 marks. The candidates will attempt five questions in all, selecting one each from the units I to IV and the compulsory question from unit V.

2. The question paper is expected to contain problems with a weightage of 30 to 40% of the total marks.

UNIT I

Nuclear Shell Model: Coupling of angular momentum - C.G. Coefficients and Racah Coefficients. Evidence for nuclear shell structure, Extreme single particle model with square-well and harmonic oscillator potentials, spin-orbit potential, Shell model predictions.

Single-particle model, total spin for various configurations, Nuclear isomerism, Magnetic moment-Schmidt lines, electric quadrupole moment,

Configuration mixing, Independent particle model, L-S coupling and jj coupling schemes. (Book 1, Book 2 and Book 4)

UNIT II

Collective Model of Nucleus: Rotation - D Matrices, Parameterization of nuclear surface, Collective surface oscillations, Derivation of the collective hamiltonian, transformation to body-fixed frame. (Book 2)

Collective modes of motion, Nuclear vibrations, β and γ vibrations in spheroidal nucleus and associated energy spectra, Iso-scalar vibrations, Giant resonances. (Book 3)

Brief overview supported by examples - Deformed rotational nuclei, rotational energy spectra for even-even nuclei and odd-A nuclei, decoupling parameter, Electric quadrupole moment and magnetic dipole moment, E2 and M1 transition probabilities, Energy spectrum with coupling of vibration and rotational motion.
(Book1, Book 2)

UNIT-III

Nuclear reactions, Resonance: Breit-Wigner Dispersion Formula, Compound Nucleus, cross section for formation of compound nucleus, Statistical theory of nuclear reactions. Optical model for nuclear reactions at low energies, comparison with experiments.

Direct Reactions - Kinematics of stripping and pick-up reactions, theory of stripping and pick-up reactions.
(Book 1)

UNIT IV

Harmonic anisotropic oscillator, Nilsson model. (Book 1)

Rotational motion at very high spins, Population of high spin states, Cranking shell model, Signature quantum number, Backbending phenomenon, Kinematics and dynamic moment of inertia. (Book 3 and Book 5)

Brief reviews - Nuclear Physics at extremes of stability, nuclear halos, proton rich nuclei, Radioactive ion beams, Production of superheavy nuclei (Book 3)

TUTORIALS: Relevant problems given at the end of each section in the text books.

Books:
1. Nuclear Physics: R.R. Roy and B.P. Nigam, (New Age, New Delhi) (2009).
2. Theory of Nuclear Structure: M. K. Pal, (East-west Press, New Delhi) (1992).
3. Basic Ideas and Concepts in Nuclear Physics: K. Heyde, (Overseas Press India) (2005).
4. Elementary theory of Angular momentum: M.E. Rose (Dover edition) (1995).
5. Nuclear Physics: Experimental and Theoretical: H. S. Hans, (New Academic Science Ltd., Second Revised edition) (2010).

M.Sc.-3rdSEMESTER
PHY7004   **CONDENSED MATTER PHYSICS-I**

> **Max. Marks: 15+60=75**
> **Total teaching hours : 60**

Objectives:

The aim and objective of the course on Condensed Matter Physics I is to make the students of M.Sc class familiar to the Solid structure, lattice dynamics, elastic constants, dielectric properties, energy band theory and transport theory so that they are prepared with the techniques used in investigating these aspects of the matter in condensed phase.

Note :

1. The question paper for the final examination will consist of five units. Unit I-IV will have TWO questions each from the corresponding units of the syllabus. Unit V in the paper will have one compulsory question consisting of 5 to 8 short answer type questions covering the whole syllabus. Each question will have a weightage of 12 marks. The candidates will attempt five questions in all, selecting one each from the units I to IV and the compulsory question from unit V.

2. The question paper is expected to contain problems with a weightage of 30 to 40% of the total marks.

UNIT-I

Structure and lattice dynamics

Bragg Law, Reciprocal lattice vectors, Structure factor, Form factor [Book 1]

Forces between atom: ionic bonding, cohesive energy of ionic crystal, evaluation of Madelung constant of NaCl structure, covalent bonding, metallic bonding, hydrogen bonding, van der waals bonding [Book 2]

Stress components, displacement and strain components, work done by elastic forces in a solid, reduction of no. of elastic constant due to existence of potential of elastic forces. Elastic stiffness constant for isotropic body, elastic waves, waves in [100] and [110] directions [Book 3]

Dynamics of the chain of identical atoms, dynamics of a diatomic linear chain, dynamics of identical atoms in three dimensions, experimental measurements of dispersion relations, anharmonicity and thermal expansion. [Book 2]

UNIT-II

Band theory

Bloch theorem, the Kronig-Penney model, zone schemes, effective mass of electron, nearly free electron model, tight binding approximation, OPW method, pseudo potential method, conductors semiconductors insulators [Book 2]

UNIT-III

Transport theory

Electronic transport from classical kinetic theory; Boltzmann transport equation, electrical conductivity, calculation of relaxation time in metals, thermal conductivity of metals and insulators, thermoelectric effects; Hall effect and magnetoresistance; Transport in semiconductors. [Book 4]

UNIT-IV

Dielectric properties

Polarization mechanisms, Dielectric function from oscillator strength, dielectric constant and its measurements, ploarizability, the classical theory of electronic ploarizabilty, Clausius-Mosotti relation; dipolar polarizability.

Piezo- pyro and ferroelectric properties of crystals, ferroelectricity, ferroelectric domain, antiferroelectricity and ferrielectricity
[Book 1 and Book 2]

Books

1. Introduction to Solid state Physics: C Kittel (7th edition, New York) (2007)
2. Solid state Physics: M A Wahab (2nd edition , Narosa, New Delhi) (2006)
3. Solid State Physics: Theory, Applications & Problems, S. L. Kakani and C Hemrajajani (Sultan Chand & Sons, Delhi) (2014)
4. Principles of the theory of solids: J M Ziman (2nd edition, Cambridge Univ. press) (1979)

M.Sc.-3rdSEMESTER
PHY 7021   **PHYSICS LABORATORY III**

> **Max. Marks : 150**
> **Teaching hours: 9 hrs per week**

Objective: The aim and objective of the courses on Physics Laboratory III and Physics Laboratory IV is to train the students of M.Sc. class to advanced experimental techniques in general physics, electronics, nuclear physics, particle physics and condensed matter physics so that they can investigate various relevant aspects and are confident to handle sophisticated equipment and analyze the data.

Note: Students are expected to perform at least 10 experiments in each semester taking 5 from each of the sections A and B. The experiments performed in third semester cannot be repeated in fourth Semester.

Section-A

1. Study of arc emission spectrum of given samples (Fe and Cu).
2. Refractive index of air using Jamin's Interferometer.
3. To study the Michelson interferometer and its applications.
4. To study optical polarization by reflection - Determination of Brewester's angle.
5. To measure numerical aperture and propagation loss and bending losses for optical fibre as function of bending angle and at various wavelengths.
6. To study the intensity profile of the diffraction pattern of single slit and verify the uncertainty principle by using LASER.
7. To determine the gamma-ray absorption coefficient for Pb, Sn and Fe elements and Pb-Sn alloy.
8. To study the alpha spectrum from natural sources Th and U.
9. To calibrate the given gamma-ray spectrometer and determine its energy resolution.
10. To calibrate the given gamma-ray spectrometer and determine its energy resolution using multi-channel analyzer. To determine strength of a ^{60}Co source by sum-peak method.
11. To determine range of Alpha-particles in air at different pressure and energy loss in thin foils.
12. To determine strength of alpha particles using SSNTD.
13. To study $\overline{p} - p$ interaction and find the cross-section of a reaction using a bubble chamber.
14. To study $\overline{n} - p$ interaction and find the cross-section using a bubble chamber.
15. To study K^+- d interaction and find its multiplicity and moments using a bubble chamber.
16. To determine the g-factor of free electron using ESR.
17. To study thermoluminescence of trapping-centres produced by UV in doped CuS.
18. To measure dielectric constant of barium titanate as function of temperature and frequency and hence study its phase transition.
19. Determination of velocity of light using modulated Laser method.

Section-B

1. To design and assemble an Integrated circuit regulated power supply with output of both polarities and a current regulator.
2. To design and study a constant current source.
3. To study of the Switched-mode power supply.
4. To study FET/MOSFET characteristics, biasing and its applications as an amplifier.
5. To measure characteristic parameters of an OPAMP and use of operational amplifier for different mathematical operations.
6. To design a rectangular/triangular waveform generator using Comparators and IC8038.
7. To design (i) Low pass filter (ii) High pass filter (iii) All-pass filter using 741 OPAMP.
8. To design (i) Band pass filter (ii) Band-reject filter using 741 OPAMP.
9. To configure various shift registers and digital counters.
10. Use of timer IC 555 in astable and monostable modes and applications involving relays and LDR.
11. (i) Study of the characteristics of klystron tube and to determine its electronic tuning range;

    To determine the standing wave ratio and reflection coefficient; (iii) To determine the frequency & wavelength in a rectangular waveguide working on TE_{10} mode; (iv) To study the square law behaviour of a microwave crystal detector.
12. Experiments with microwave (Gunn diode): Young's double slit experiment, Michelson interferometer, Febry-Perot interferometer, Brewester angle, Bragg's law, refractive index of a prism.
13. Analog to digital and Digital and analog measurements based experiments (Phoenix Kit, IUAC, New Delhi).
14. Microprocessor kit: (a) hardware familiarization (b) programming for (i) addition and subtraction of numbers using direct and indirect addressing modes (ii) Handling of 16 bit numbers (iii) use of CALL and RETURN instructions and block data handling.
15. Use of Digital storage oscilloscope Two Applications for (a) plotting v-i characteristics; and measuring speed of e.m. waves in coaxial cables.
16. Frequency modulation using Varactor/Reactance modulator and Frequency demodulation using Quadrature detector/Phased Locked Loop detector.

M.Sc.-3rdSEMESTER
PHYS 7022   COMPUTATIONAL PHYSICS I Lab (Practical Paper)

Max. Marks: 50
Teaching hours: 4 hrs per week

Note : The Computational Physics paper will consist of two parts –

1. Written examination for 40% of the total marks covering Unit I and Unit II with equal weightage and duration one hour. Question paper will be set by the external examiner.
2. Practical examination for 60% of the total marks and duration two hours.

Unit I

Introduction to Numerical methods: Computer algorithms, interpolations –cubic spline fitting, Numerical differentiation – Lagrange interpolation, Numerical integration by Simpson and Weddle's rules, random generators, Numerical solution of differential equations by Euler, predictor-corrector and Runge-Kutta methods, problems.

Unit II

Computer hardware, software, C++ Programming
Language Algorithms, Structured Programming.

Data and Statements : Data Types. Constants and Variables. Mathematical, Relational, Logical and Bitwise Operators. Expressions and Statements. Block, Local and Global variables. Auto, Static and External Variables.

I/O Statements : printf, scanf, getc, getch, getchar, getche, etc. Streams : cin and cout. Manipulators for Data Formatting: setw, width, endl and setprecision etc. ASCII Files I/O. Preprocessor : #include and #define directives.

Control Statements :- If-statement. If-else Statement. Nested if Structure. Else-if Statement. Ternary Operator. Goto Statement. Switch Statement. Unconditional and Conditional Looping. While Loop. Do-while Loop. For Loop. Break and Continue Statements. Nested Loops.
Arrays and Structures :- One and Two Dimensional Arrays. Idea of Structures.

Unit III

List of Numerical Problems:

1. Data handling: find standard deviation, mean, variance, moments etc. of at least 25 entries.
2. Choose a set of 10 values and find the least squared fitted curve.
3. Generation of waves on superposition like stationary waves and beats.
4. Fourier analysis of square waves.
5. To find the roots of quadratic equations.
6. Wave packet and uncertainty principle.
7. Find first order derivative at given x for a set of 10 values with the help of Lagrange interpolation.
8. To generate random numbers between (i) 1 and 0, (ii) 1 and 100.
9. Perform numerical integration on 1-D function using Simpson and Weddle rules.
10. To find determinant of a matrix - its eigenvalues and eigenvectors.

Books

1. Numerical Mathematical Analysis, J.B. Scarborough (Oxford Book Co.) 4th edition.
2. A first course in Computational Physics: P.L. DeVries (Wiley) 2nd edition 2011.
3. Computer Applications in Physics: S. Chandra (Narosa)2nd edition (2008).
4. Computational Physics: R.C.Verma, P.K. Ahluwalia and K.C. Sharma (New Age) 1st edition (2005).
5. Object Oriented Programming with C++: Balagurusamy, (Tata McGrawHill) 2nd edition (2002).

M.Sc.- 4th SEMESTER

M.Sc.- 4th SEMESTER
PHY 7051   **PARTICLE PHYSICS II**

Max. Marks: 15+60 = 75
Total teaching hours : 60

Objectives:

The aim and objective of the course on Particle Physics II is to expose the students of M.Sc. class to the relatively advanced topics like internal symmetries and quark model, details of different types of fundamental interactions and unification schemes so that they understand these aspects properly and are well equipped to pursue a career in high energy physics.

Note :

1. The question paper for the final examination will consist of five units. Unit I-IV will have TWO questions each from the corresponding unit of the syllabus. Unit V in the paper will have one compulsory question consisting of short answer type questions covering the whole syllabus. The compulsory question will not have any choice. Each question will have a weightage of 12 marks. The candidates will attempt five questions in all, selecting one each from the units I to IV and the compulsory question from unit V.

2. The question paper is expected to contain problems with a weightage of 30 to 40 % of the total marks.

UNIT I

Internal Symmetries: Introduction to Symmetries Discrete symmetries. Continuous Symmetries. Permutation Symmetry. Example. Young's Tables and their relation to group theory. Symmetry groups O(3), SU(2), SU(3) and SU(6). Applications of symmetry groups to hadron spectroscopy: meson mixing, mass formulae.

UNIT II

Quark Model : Introduction to constituent quark model, Quantum number of quarks & valence quark contents of hardrons, simple applications to hadron phenomenology, e.g., unitary spin & spin hadron wave function of baryons and mesons.

Electromagnetic Interactions : Low energy e-p scattering and form factors. Electromagnetic form factors of nucleons. Deep inelastic structure functions and introduction to parton model. Gauge invariance local, Global Transformations and charge conservation. Noether's Theorem.

UNIT III

Weak Interactions : Introduction to four fermion Fermi theory. Fermi transitions. Gamow Teller transitions. Development of V-A theory. Weak neutral current and GIM model. Neutrino-nucleon scattering. Introduction to $c\bar{c}$ and $b\bar{b}$ system.

Strong Interactions : Introduction to gauge field theories, including Non-Abelian gauge field (motivation, construction and consequences of Yang-Mills theory). Elements of QCD.

UNIT IV

Unification Schemes : Spontaneous symmetry breaking, Introduction to Glashow-Weinberg-Salam model, Standard model-introduction and Lagrangian. Higgs boson. .

TUTORIALS : Relevant problems given at the end of each chapter in the books listed below.

Books

1. An Introduction to Elementary Particles : D.H. Perkins (Addison Wesley, Reading) 4th edition (2001).
2. Introduction to Quarks and Partons : F.E. Close (Academic Press, London) (1981).
3. Introduction to Particle Physics : M.P. Khanna (Prentice-Hall of India, New Delhi) 3rd edition (2004).
4. Gauge Theories of Weak, Strong and Electromagnetic Interactions: C Quigg (Gorden & Breach, New York) (1994).
5. Gauge Theory of Elementary Particle Physics : T.P Cheng and L.F. Li (Oxford University Press, Oxford) (1982).
6. Introduction to Quantum Electrodynamics and Particle Physics: D.C. Joshi (I.K. International Publishing House Pvt. Ltd., New Delhi) (2006).
7. Elementary Particles: I.S. Hughes (Cambridge University Press, Cambridge) 3rd edition (1996).

M.Sc.- 4th SEMESTER
PHY 7052   CONDENSED MATTER PHYSICS II

Max. Marks: 15+60 = 75
Total teaching hours : 60

Objectives:

The aim and objective of the course on Condensed Matter Physics II is to expose the M.Sc. students with relatively advanced topics like optical properties, magnetism, superconductivity and disordered solids so that they are confident to use the relevant techniques in their later career.

Note :

1. The question paper for the final examination will consist of five units. Unit I-IV will have TWO questions each from the corresponding unit of the syllabus. Unit V in the paper will have one compulsory question consisting of short answer type questions covering the whole syllabus. The compulsory question will not have any choice. Each question will have a weightage of 12 marks. The candidates will attempt five questions in all, selecting one each from the units I to IV and the compulsory question from unit V.
2. The question paper is expected to contain problems with a weightage of 30 to 40 % of the total marks.

UNIT-I

Optical properties : Propagation of light in isotropic solids, propagation of light in conducting media, absorption processes, photo conductivity, luminescence. Piezoeletricity and ferroeletricity.

[Book 1]

UNIT-II

Magnetism : Dia- and para-magnetism in materials, Pauli paramagnetism, Ferromagnetism, Heisenberg Hamiltonian and resume of the results; Antiferomagnestim, Ferrimagnetism, ferrites, spin waves, specific heat - Bloch law, Magnons.
[Book 1]

UNIT-III

Superconductivity: Source of superconductivity, response of magnetic field, the Meissner effect, Type I and Type II superconductors; thermodynamics of superconducting transitions, origin of energy gap, iosotope effect, London equatios, London penetration depth, coherence length, elements of BCS theory, flux quantization, normal tunneling and Josephson effect, high Tc superconductors.
[Book 2 and Book 4]

UNIT-IV

Defects and disorders: Point Imperfections, concentration of point imperfections, line imperfections, Burgers vector and circuit, presence of dislocation, dislocation motion, energy of a dislocation, slip planes and slip directions, surface imperfections. [Book 2]

Types of liquid crystals, classification, calamitic thermotropic liquid crystals, lyotropic liquid crystals, mesogenic materials
[Book 3 and Book 4]

TUTORIALS : Relevant problems given at the end of each chapter in the books listed below.

Books
1 Solid State Physics: S. L. Kakani and C Hemrajajani (2nd edition, Sultan Chand and Sons, Delhi.
2 Solid State Physics: M A Wahab (2nd edition, Narosa, New Delhi).
3 Liquid Crystals Fundamentals: Shri Singh (World Scientific Publishing Co. Pvt. Ltd.) (2002).
4 Solid State Physics : H. Ibach and H. Luth (4th edition, Springer, Berlin) 2010.
5 Introduction to Solid State Physics : C. Kittel (7th edition Wiley, New York) (2008).
6 Quantum Theory of Solids : C. Kittel (2_{nd} edition, Wiley, New York) (1987).
7 Principles of the Theory of Solids : J. Ziman (2_{nd} edition, Cambridge University Press, Cambridge) (1972).

M.Sc.- 4th SEMESTER
PHY 7071   **Physics Laboratory IV**

Max. Marks : 150
Teaching hours: 9 hrs per week

Objective: The aim and objective of the courses on Physics Laboratory III and Physics Laboratory IV is to train the students of M.Sc. class to advanced experimental techniques in general physics, electronics, nuclear physics, particle physics and condensed matter physics so that they can investigate various relevant aspects and are confident to handle sophisticated equipment and analyze the data.

Note: Students are expected to perform at least 10 experiments in each semester taking 5 from each of the sections A and B. The experiments performed in third semester cannot be repeated in fourth Semester.

Section-A

1. Study of arc emission spectrum of given samples (Fe and Cu).
2. Refractive index of air using Jamin's Interferometer.
3. To study the Michelson interferometer and its applications.
4. To study optical polarization by reflection - Determination of Brewester's angle.
5. To measure numerical aperture and propagation loss and bending losses for optical fibre as function of bending angle and at various wavelengths.
6. To study the intensity profile of the diffraction pattern of single slit and verify the uncertainty principle by using LASER.
7. To determine the gamma-ray absorption coefficient for Pb, Sn and Fe elements and Pb-Sn alloy.
8. To study the alpha spectrum from natural sources Th and U.
9. To calibrate the given gamma-ray spectrometer and determine its energy resolution.
10. To calibrate the given gamma-ray spectrometer and determine its energy resolution using multi-channel analyzer. To determine strength of a ^{60}Co source by sum-peak method.
11. To determine range of Alpha-particles in air at different pressure and energy loss in thin foils.
12. To determine strength of alpha particles using SSNTD.
13. To study p-p interaction and find the cross-section of a reaction using a bubble chamber.
14. To study n-p interaction and find the cross-section using a bubble chamber.
15. To study k-d interaction and find its multiplicity and moments using a bubble chamber.
16. To determine the g-factor of free electron using ESR.
17. To study thermoluminescence of trapping-centres produced by UV in doped CuS.
18. To measure dielectric constant of barium titanate as function of temperature and frequency and hence study its phase transition.
19. Determination of velocity of light using modulated Laser method.

Section-B

1. To design and assemble an Integrated circuit regulated power supply with output of both polarities and a current regulator.
2. To design and study a constant current source.

1. To study of the Switched-mode power supply.
2. To study FET/MOSFET characteristics, biasing and its applications as an amplifier.
3. To measure characteristic parameters of an OPAMP and use of operational amplifier for different mathematical operations.
4. To design a rectangular/triangular waveform generator using Comparators and IC8038.
5. To design (i) Low pass filter (ii) High pass filter (iii) All-pass filter using 741 OPAMP.
6. To design (i) Band pass filter (ii) Band-reject filter using 741 OPAMP.
7. To configure various shift registers and digital counters.
8. Use of timer IC 555 in astable and monostable modes and applications involving relays and LDR.
9. (i) Study of the characteristics of klystron tube and to determine its electronic tuning range; To determine the standing wave ratio and reflection coefficient; (iii) To determine the frequency & wavelength in a rectangular waveguide working on TE_{10} mode; (iv) To study the square law behaviour of a microwave crystal detector.
10. Experiments with microwave (Gunn diode): Young's double slit experiment, Michelsoninterferometer, Febry-Perot interferometer, Brewester angle, Bragg's law, refractive index of a prism.
11. Analog to digital and Digital and analog measurements based experiments (Phoenix Kit, IUAC, New Delhi).
12. Microprocessor kit: (a) hardware familiarization (b) programming for (i) addition and subtraction of numbers using direct and indirect addressing modes (ii) Handling of 16 bit numbers (iii) use of CALL and RETURN instructions and block data handling.
13. Use of Digital storage oscilloscope Two Applications for (a) plotting v-i characteristics; and measuring speed of e.m. waves in coaxial cables.
14. Frequency modulation using Varactor/Reactance modulator and Frequency demodulation using Quadrature detector/Phased Locked Loop detector.

M.Sc.- 4th SEMESTER
PHYS 7073   **Computational Physics II**

Max. Marks: 50
Teaching hours: 4 hrs per week

Note : The Computational Physics paper will consist of two parts –

1. Written examination for 30% of the total marks covering Unit I and duration one hour. Question paper will be set by the external examiner.
2. Practical examination for 70% of the total marks and duration two hours.

Unit I

C++ Programming Language
Functions :- Standard Library Functions and User-defined Functions. Void Functions and Functions returning Values. Function Prototypes. Function Call by Value and by Reference. Recursion. Idea of Function Overloading.

Idea of Classes, Objects and Inheritance :- Classes and Objects. Member Functions in a class. Private and Public Qualifiers and Data Security. Constructors and Destructors. Inheritance.
Idea of Strings and Pointers.

Unit II

List of Physics Problems.

Note: Do at least 10 problems using C^{++} programming.

20. Study the charging and discharging of a capacitor in RC circuit with a DC source using Eulermethod. Graphically demonstrate the variation of charge with time for two values of time step size. Modify the program to include AC source instead of D.C. Source.

21. Study the growth and decay of current in RL circuit containing (a) DC source and (b) AC source using Runge Kutta method. Draw graphs between current and time in each case. Perform power analysis in the circuit for two values of time step size for the case.

22. Write a program to study graphically the EM oscillations in a LCR Circuit (use Runge-Kutta method). Show the variations of (a) charge vs time, (b) current vs time.

23. Study graphically the motion of a falling spherical body under various effects of the medium (viscous drag, buoyancy and air drag) using Euler method.

24. Study graphically the path of a projectile with and without air drag, using FN method. Find the horizontal range and maximum height in either case. Write your comments on the findings.

25. Motion of artificial satellite.

26. Study of motion of a one-dimensional harmonic-oscillator without and with damping effect (use Euler method). Draw graphs showing the relations (a) velocity vs time (b) acceleration vs time (c) position vs time.

27. Obtain the energy eigen values of a quantum oscillator using Runge-Kutta method.

28. Study the motion of a charged particle in (a) uniform electric field (b) in uniform magnetic field (c) in combined electric and magnetic fields (cyclotron). Draw graphs in each case.

29. Monte-Carlo technique to simulate phenomenon of Nuclear radioactivity. Modify your program to a case when daughter nucleus is also unstable.

30. Study the motion of two coupled harmonic oscillators. Compare the numerical results with analytic results.

Books
1 Numerical Mathematical Analysis, J.B. Scarborough (Oxford Book Co.) 5th edition, (1964).
2 A first course in Computational Physics: P.L. DeVries (Wiley) (1994).
3 Computer Applications in Physics: S. Chandra (Narosa) 2nd edition, (2008).
4 Computational Physics: R.C. Verma, P.K. Ahluwalia and K.C. Sharma (New Age) 1st edition (1999).

M.Sc.- 4th SEMESTER
PHYS7053   Experimental techniques in Nuclear and Particle Physics

Max. Marks: 15+60 = 75
Total Teaching Hours : 60

Objectives: The aim and objective of the course on Experimental Techniques in Nuclear, Particle and Condensed Matter Physics is to expose the students of M.Sc. class to theoretical aspects of different equipment and methods used in the fields of Nuclear and Particle Physics.

Note:

35.   The question paper for the final examination will consist of five units. Unit I-IV will have TWO questions each from the corresponding unit of the syllabus. Unit V in the paper will have one compulsory question consisting of short answer type questions covering the whole syllabus. The compulsory question will not have any choice. Each question will have a weightage of 12 marks. The candidates will attempt five questions in all, selecting one each from the units I to IV and the compulsory question from unit V.

36.   The question paper is expected to contain problems with a weightage of 30 to 40 % of the total marks.

Unit I

Data interpretation and analysis, precision and accuracy, error analysis, propagation of errors, Statistical treatment of experimental data. Least squares fitting of linear and nonlinear functions, chi-square test, Binomial, Poisson and Gaussian distributions.

Detection of radiations:

Interaction of gamma-rays, neutrons, electrons and heavy charged particles with matter, Relativistic particle interaction.

General properties of radiation detectors, pulse height spectra, energy resolution, detection efficiency, dead time.

Back ground radiation and detector shielding.

(Book 1 and Book 2)

Unit II

Gas-filled detectors : Proportional counters, Gas multiplication factor, space charge effects, energy resolution. Position-sensitive proportional counters.

Organic and inorganic scintillators and their characteristics, coupling to photomultiplier tubes and photodiodes.

Semiconductor detector in X-ray, gamma-ray Spectroscopy, Ge and Si(Li) detectors, Charge production and collection process.

Semiconductor detector in particle identification and Charged particle Spectroscopy (Telescope arrangement, time of flight).

Detection of fast and slow neutrons - nuclear reactions for neutron detection.

(Book 1 and Book 2)

Unit III

Electronics associated with detectors : Electronic shielding and grounding, Measurement and control, Signal conditioning and recovery.

Electronics for pulse signal processing, preamplifiers (voltage and charge-sensitive configurations), Linear amplifiers, CR-$(RC)^n$ and delay-line pulse shaping, pole-zero cancellation, baseline shift and restoration, overload recovery and pileup, Impedance matching, single-channel and multichannel analyzers.

Basic considerations in time measurements, Walk and jitter, Time pickoff methods, time-to-amplitude converters, γγ fast-slow coincidence set up.

(Book 1)

Unit IV

Detector systems for heavy-ion reactions : Large gamma and charge particle detector arrays, multiplicity filters, electron spectrometer, heavy-ion reaction analysers. nuclear lifetime measurements (DSAM and RDM techniques).

Detector systems for high energy experiments (brief account): Collider physics, Particle Accelerators, Secondary beams, Beam transport, Modern Hybrid experiments - CMS and ALICE. (Book 1 and Book 3)

Books:
1. Radiation detection and measurement: G.F. Knoll (Wiley, New York) (2000).
2. Techniques for Nuclear and Particle Physics experiments: W.R. Leo (Springer) (1994).
3. Introduction to Experimental Particle Physics: Richard Fernow, (Cambridge University Press, Cambridge) (1989).

M.Sc.- 4th SEMESTER
PHYS7054   **Fibre Optics and Non-Linear Optics**

Max. Marks: 15+60 = 75
Total teaching hours : 60

Objectives: The aim and objective of the course on Fibre Optics and Nonlinear Optics is toexpose the M.Sc. students to the basics of the challenging research field of optical fibers and their use in nonlinear optics.

Note:
1. The question paper for the final examination will consist of five units. Unit I-IV will have TWO questions each from the corresponding unit of the syllabus. Unit V in the paper will have one compulsory question consisting of short answer type questions covering the whole syllabus. The compulsory question will not have any choice. Each question will have a weightage of 12 marks. The candidates will attempt five questions in all, selecting one each from the units I to IV and the compulsory question from unit V.
2. The question paper is expected to contain problems with a weightage of 30 to 40 % of the total marks.

UNIT I

Optical fibre, its properties and fabrication : Introduction, basic fibre construction, propagation of light, modes and the fibre, refractive index profile, types of fibre, dispersion, data rate and band width, attenuation, leaky modes, bending losses, cut-off wavelength, mode field diameter, other fibre types. (Ch. 3 of book 1)

Fibre fabrication, mass production of fibre, comparison of the processes, fibre drawing process, coatings, cable design requirements, typical cable design, testing. (Ch. 4 of book 1)

UNIT II

Optics of anisotropic media: Introduction, the dielectric tensor, stored electromagnetic energy in anisotropic media, propagation of monochromatic plane waves in anisotropic media, directions of D for a given wave vector, angular relationships between D, E, H, k and Poynting vector S, the indicatrix, uniaxial crystals, index surfaces, other surfaces related to the uniaxial indicatrix, Huygenian constructions, retardation, biaxial crystals, intensity through polarizer/waveplate/polarizer combinations.
(Ch. 18 of book 2)

UNIT III

Electro-optic and acousto-otpic effects and modulation of light beams: Introduction to the electro-optic effects, linear electro-optic effect, quadratic electro-optic effects, longitudinal electro-optic modulation, transverse electro optic modulation, electro-optic amplitude modulation, electro-optic phase modulation, high frequency wave guide, electro-optic modulator, strain optic tensor, calculation of LM for a longitudinal acoustic wave in isotropic medium, calculation of LM for a shear wave in lithium niobate, Raman-Nath diffraction, Raman-Nath acousto-optic modulator.
(Ch. 19 of book 2,Ch. 16, 17 & 19 of book 3)

UNIT IV

Nonlinear optics and processes : Introduction, anharmonic potentials and nonlinear polarization, non-linear susceptibilities and mixing coefficients, parametric and other non-linear processes, macroscopic and microscopic susceptibilities.

TUTORIALS: Relevant problems pertaining to the topics covered in the course.

Books
1. The Elements of Fibre Optics: S.L.Wymer and Meardon (Regents/Prentice Hall) (1993).
2. Lasers and Electro-Optics: C.C. Davis (Cambridge University Press) (2000).
3. Optical Electronics : Gathak & Thyagarajan (Cambridge Univ. Press) (1989).
4. The Elements of Non-linear Optics: P.N. Butcher & D. Cotter (Cambridge University Press) (1990).

M.Sc.- 4th SEMESTER
PHYS 7055   NON-LINERAR DYNAMICS

Note :

1. The question paper for the final examination will consist of five units. Unit I-IV will have TWO questions each from the corresponding unit of the syllabus. Unit V in the paper will have one compulsory question consisting of short answer type questions covering the whole syllabus. The compulsory question will not have any choice. Each question will have a weightage of 12 marks. The candidates will attempt five questions in all, selecting one each from the units I to IV and the compulsory question from unit V.

2. The question paper is expected to contain problems with a weightage of 30 to 40 % of the total marks.

UNIT I

Phenomenology of Chaos : Linear and nonlinear systems, A nonlinear electrical system, Biological population growth model, Lorenz model; determinism, unpredictability and divergence of trajectories, Feigenbaum numbers and size scaling, self similarity, models and universality of chaos.

UNIT II

Dynamics in State Space: State space, autonomous and non autonomous systems, dissipative systems, one dimensional state space, Linearization near fixed points, two dimensional state space, dissipation and divergence theorem. Limit cycles and their stability, Bifurcation theory, Heuristics, Routes to chaos. Three-dimensional dynamical systems, fixed points and limit cycles in three dimensions, Lyapunov exponents and chaos. Three dimensional iterated maps, Usequence.

UNIT III

Hamiltonian System : Non-integrable systems, KAM theorem and period doubling, standard map. Applications of Hamiltonian Dynamics, chaos and stochasticity.

UNIT IV

Quantifying Chaos: Time series, Lyapunov exponents. Invariant measure, Kolmogorov - Sinai entropy.Fractal dimension, Statistical mechanics and thermodynamic formalism.

Quantum Chaos: Quantum Mechanical analogies of chaotic behaviour. Distribution of energy eigenvalue spacing, chaos and semi-classical approach to quantum mechanics.

TUTORIALS : Relevant problems pertaining to the topics covered in the course.

Books
1. Chaos and Non Linear Dynamics : R.C. Hilborn (Oxford Univ. Press) (2000).
2. Chaos in Dynamical Systems : E. Ott (Cambridge Univ. Press) (2002).
3. Applied Nonlinear Dynamics : A.H. Nayfeh and B. Balachandran (Wiley) (1995).
4. Chaos in Classical and Quantum Mechanics : M.C. Gutzwiller (Springer-Verlag) (1990).

M.Sc.- 4th SEMESTER
PHYS 7056　　　　　　　**PARTICLE ACCELERATOR PHYSICS**

Max. Marks: 15+60 = 75
Total teaching hours : 60

Note :

1. The question paper for the final examination will consist of five units. Unit I-IV will have TWO questions each from the corresponding unit of the syllabus. Unit V in the paper will have one compulsory question consisting of short answer type questions covering the whole syllabus. The compulsory question will not have any choice. Each question will have a weightage of 12 marks. The candidates will attempt five questions in all, selecting one each from the units I to IV and the compulsory question from unit V.

2. The question paper is expected to contain problems with a weightage of 30 to 40 % of the total marks.

UNIT I
Charged Particle Dynamics : Particle motion in electric and magnetic fields, Beam transport system, Beam pulsing and bunching techniques, microbeams, Particle and ion sources, secondary beams, Measurement of beam parameters.

UNIT II

Radiofrequency Accelerators: Linear accelerators - Resonance acceleration and phase stability, electron and proton Linacs. Circular accelerators - Cyclotron, Frequency Modulated Synchrocyclotron, AVF Cyclotron, Alternating-gradient accelerators.

UNIT III

Electrostatic and Heavy Ion Accelerators : Van de Graaff voltage generator, Cockcroft-Walton voltage generator, insulating column, voltage measurement, Acceleration of heavy ions,Tandem electrostatic accelerator, Production of heavy negative ions, Pelletron and Tandetron, Cluster beams, Superconducting Heavy Ion Linear Accelerators.

UNIT IV

Synchrotron Radiation Sources : Electromagnetic radiation from relativistic electron beams, Electron synchrotron, dipole magnet, multipole wiggler, noncoherent and coherent, Undulator, Characteristics of synchrotron radiation.

Radioactive ion beams : Production of Radioactive ion beams, Polarized beams, Proton synchrotron, Colliding accelerators.

TUTORIALS : Relevant problems given in the books listed below.

Books :
1. Particle Accelerator Physics, Vol I and II, H.J. Wiedman (Springer Verlag) (1998).
2. Particle Accelerators, M.S. Livingston and J.P. Blewel (McGraw-Hill Book Press) (1962).
3. Nuclear Spectroscopy and Reactions Part-A, Ed. J. Cerny (Academic Press) (1974).
4.Theory of Resonance Linear Accelerators by I.M. Kapchenkey (Harwood Academic Publishers) (1985).

M.Sc.- 4th SEMESTER
PHYS 7057   ANALYTICAL TECHNIQUES FOR MATERIALS

Max. Marks: 15+60 = 75
Total teaching hours : 60

Note :

1. The question paper for the final examination will consist of five units. Unit I-IV will have TWO questions each from the corresponding unit of the syllabus. Unit V in the paper will have one compulsory question consisting of short answer type questions covering the whole syllabus. The compulsory question will not have any choice. Each question will have a weightage of 12 marks. The candidates will attempt five questions in all, selecting one each from the units I to IV and the compulsory question from unit V.

2. The question paper is expected to contain problems with a weightage of 30 to 40 % of the total marks.

UNIT I

Atomic Physics : Quantum states of an electron in an atom. Electron spin. Spectrum of helium and alkali atom. Relativistic corrections for energy levels of hydrogen atom, hyperfine structure and isotopic shift, width of spectrum lines, LS & JJ couplings. Zeeman, Paschen-Bach & Stark effects.

Inner-shell ionization, X-ray spectra, Mosley law, absorption spectra, Auger effect, Coster-Kronig Transitions, Selection rules. (Book 1)
Elemental analysis : EDXRF, WDXRF, Atomic Absorption Spectrometer.
Electron spin resonance. Nuclear magnetic resonance, chemical shift. (Book 2, Book 3)

UNIT II
Molecular Physics : Molecular spectra, symmetric structures, Frank-Condon principle. Born-Oppenheimer approximation. Electronic, rotational, vibrational and Raman spectra of diatomic molecules, selection rules.
(Book 1, Book 3, Book 4)

Lasers: spontaneous and stimulated emission, Einstein A & B coefficients. Optical pumping, population inversion, rate equation. Modes of resonators and coherence length. (Book 5)

Molecular analysis: Double beam optics, UV-Vis Spectrometer, FTIR Spectrometer, Raman Spectrometer. (Book 2, Book 3)

UNIT III
Transducers : Classification, Transducers for temperature, pressure/vacuum, magnetic fields, vibration measurements, Resistive transducer, Inductive transducer, Capacitive transducer, Thermoelectric, LVDT, Strain gauge, Piezoelectric, Magnetostrictive, Hall-effect type, Electromechanical, Accelerometer.
Lock-in-detector, box-car integrator
(Book 6, Book 7)

Vacuum Techniques : Mechanical pumps, Ionization pumps, turbo molecular pumps, Vacuum gauges - Pirani and Penning. (Book 8)

UNIT IV

Sample Preparation techniques : Thin films (Physico-chemical methods), Laser ablation, Evaporation, Sputtering, Electron beam sputtering, Beam Epitaxy.

Characterization Techniques:

Structural properties: XRD, TEM, SEM, AFM, STM, Differential scanning caloriemetry, measurement of specific heat, and thermal conductivity. (Book 9 and Book 10)

Books
1. Atomic and Molecular Spectra: Rajkumar (Kedarnath Ramnath Prakashan, Meerut).
2. Undergraduate Instrumental Analysis: James W. Robinson (Marcel Dekker, New York) (1970).
3. Fundamentals of Molecular spectroscopy: Banwell and McCash (Tata McGraw Hill) (1994).
4. Molecular Structure and Molecular Spectroscopy G. Aruldhas (PHI Learning) (2009)
5. Lasers and Non-linear Optics: B.B. Laud. (Wiley Eastern) (1991).
6. Transducers and Instrumentation by D.V.S. Murty, (Prentice-Hall of India Private Limited, New Delhi), (2004).
7. Modern Electronic Instrumentation and Measurement Techniques, A.D. Helfrick and William D. Cooper, (Prentice Hall of India, New Delhi) (1990).
8. Vacuum Technology: A. Roth (North Holland) (1990).
9. Material Science and Engineering: V. Raghavan (Prentice-Hall of India, New Delhi).
10. Science of Engineering Materials: Srivastava and Srinivasan (New Age, New Delhi).

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