M.Sc. in Physics (Specialization in Electronics)

under the Framework of Honours School System

ACADEMIC SESSION 2025-2026

CHOICE BASED CREDIT SYSTEM (CBCS)

PANJAB UNIVERSITY, CHANDIGARH
OUTLINES OF TESTS, SYLLABI AND COURSES OF READING FOR CHOICE BASED CREDIT SYSTEM (CBCS)
M.Sc. IN PHYSICS (SPECIALIZAION IN ELECTRONICS)
UNDER THE FRAMEWORK OF HONOURS SCHOOL SYSTEM EXAMINATION, STARTING FROM ACADEMIC SESSION 2025-2026

Choice Based Credit System (CBCS) is one of the important measures recommended by the University Grants Commission (UGC) to enhance academic standards and quality in higher education include innovation and improvements in curriculum, teaching-learning process, examination and evaluation systems. CBCS provides an opportunity for the students to choose courses from the prescribed courses comprising Core, and Discipline Specific and Generic Elective courses. The performance of students in examinations will be evaluated following the Grading system, which provides uniformity in the evaluation and computation of the Cumulative Grade Point Average (CGPA) based on student’s performance in examinations. The grading system will facilitate student mobility across institutions within and across countries and also enable potential employers to assess the performance of students.

OBJECTIVES OF THE COURSE

The objectives of the M.Sc. Physics (Specializaion in Electronics) programme are manifold and start with understanding diverse phenomena observed in nature through the fundamental concepts of Physics using logical and mathematical reasoning. The syllabus with special emphasis on electronics will provide experimental skills of Physics subject. It imparts students with an in-depth knowledge and understanding through the Core courses, which form the basis of Physics, namely, Classical Mechanics, Quantum Mechanics, Mathematical Physics, Electronics, Statistical Mechanics and Thermodynamics, Electromagnetic Theory, Solid State Physics, Nuclear Physics, Particle Physics and Atomic and Molecular Physics. The Discipline Specific elective courses are designed for more specialized Physics content to equip students with experimental and theoretical techniques. The Generic elective courses are designed for interdisciplinary content to equip students with a broader knowledge base.

Creative thinking and problem solving capabilities are also aimed to be encouraged through tutorials. The laboratory-based courses are designed to develop an appreciation for the fundamental concepts and their applications, Instrumentation, Scientific methods/tools of Physics and Electronics skills. Computational physics course is aimed to equip the students to use computers as a tool for scientific investigations/understanding. The Project work in theory and experimental stream are expected to give a flavor of how research leads to new findings. Exposure to the Advanced instruments in the Expeimental Physics will promote the research skills of students.

The M.Sc. course lays a solid foundation for a doctorate in Physics and its Allied subjects later. Major portions of the National Entrence Test (NET for Research Fellowship and Teaching Posts) syllabi are covered in the first two semesters of the course. The syllabi have been so designed that students are eligible for NET in both the subjects, Physics and Electronics. M.Sc (Hons. School) Physics (Specialization in Electronics) is equivalent to M.Sc (2-year Course) Physics being run in colleges affiliated to Panjab University. Thorough grounding in the subject will also enable students to teach Physics at the college and school levels. The Course content also covers Industrial visit of the students on individual or small group basis to inculcate the entrepreneurship character in students.

PREAMBLE

Physics is the science that involves the study of matter and its motion through space and time, along with related concepts. One of the most fundamental scientific disciplines, the main goal of physics is to understand how the universe evolved and behaves. New ideas in physics often explain the fundamental mechanisms of other sciences and the boundaries of physics are not rigidly defined. Physics also makes significant contributions through advances in new technologies that arise from theoretical breakthroughs.

After partition of India, the Department of Physics was re-established in 1947, in Govt. College, Hoshiarpur (Punjab) and later, shifted to the present campus in August 1958. With the modest beginning of research in high-energy particle physics (nuclear emulsion) and optical UV spectroscopy, the research activities got a major filip with installation of cyclotron accelerator in late sixties. The department strengthened its research activities through UGC Special Assistance Programme (SAP) from 1980 to 1988 and College Science Improvement Programme from 1984 to 1991. In 1988, the department was accorded the status of Center of Advanced Study (CAS) by UGC with three major thrust areas, Particle physics, Nuclear physics and Solid-state physics, which is a unique feature in itself. The department is now in CAS fifth phase. The department participates in various national and international research initiatives in Accelerator-based reaserch in High Energy Physics, Nuclear Physics and Solid-State Physics. The department houses Cyclotron lab, EDXRF lab., Detector development lab., Experimental Solid-state Physics laboratories, Molecular Physics lab. and Advanced computation facilities for analyses of data from High Energy Physics, and Nuclear Spectroscopy and Reaction experiments. High Performance Computation facility is available for Condensed matter Physics and Nuclear Physics simulation calculations.

The Physics department is running undergraduate and postgraduate courses in Physics, and Physics (Specialization in Electronics) under the Honours School System. At present the department has strength of about 30 faculty members and Post-doctoral fellows, 50 non-teaching/administrative staff, 130 research students and 450 graduate and undergraduate students. The department has well equipped Practical and computing laboratories, Workshops and Library. The department has an 11-inch telescope to encourage/inculcate the scientific temper among public and with particular emphasis on college and school students. The department houses Indian Association of Physics Teachers (IAPT) office and actively leads in IAPT and Indian Physics Association (IPA) activities.

COURSE STRUCTURE

M.Sc. IN PHYSICS (SPECIALIZAION IN ELECTRONICS) UNDER THE FRAMEWORK OF HONOURS SCHOOL SYSTEM

'The M. Sc. programme under the framework of Honours School System is a two-year course divided into four-semesters with a total of 80 credits. A student is required to complete 80 credits for the completion of the course and the award of degree. In general, one-hour lecture per week equals 1 Credit, 2 hours practical class per week equals 1 credit.

Subjects offered in the M.Sc. Course is divided into three categories:

(i) 'Core Course' means a course that is Compulsory for a particular programme and offered by the Department, where the student is admitted.

(ii) 'Discipline Specific Elective (DSE) Course' means an optional course to be selected by a student out of such courses offered by the Department, where the student is admitted.

(iii) 'Generic Elective (GE)' means an elective course which is taken by the students in the department other than where the student is admitted.

Syllabus (Teaching and Examination)

The details related to admissions, teaching, and conduct & evaluation of the examinations of students are given in a separate document "Regulations of the M.Sc. under the framework of Honours School System". The teaching hours and credits allocation, and the question paper pattern for the Mid Term and End-semester examinations and their evaluations for various courses of M.Sc. are given in syllabus of each Course, which is supplemented by the procedures given below:

1. **TEACHING :** The number of Lectures mentioned for each Course is 60 (45 + 15) hours, which includes 45 contact hours of teaching to be delivered exclusively by the Teacher as per the scheduled time table and 15 contact hours are for interaction, discussion, tutorials, assignments and seminars (attended/ delivered) by the student.
2. **EXAMINATION** : There shall be Mid-term Examination (75 min duration) of 20% Marks for theory papers in each semester. End-semester examinations (3 hours duration) shall be of 80% of total marks. The question paper for the Mid-term examinations should be such that more emphasis is given to the problems related to the subject. The student will be given 70% choice in attempt. Only in special cases, where the student misses the mid-term examination, retest for the mid-

term examinations will be held. For a student who has used first mid term examination chance, teacher may allow him/her to take another midterm test but the maximum score 80% of the first chance of the mid-term test.

The End-semester question paper will consist of seven questions in all with equal weightage. It will include one Compulsory question (consisting of short answer type questions) covering whole syllabus. There will be no choice in this question. The candidate will be asked to attempt five questions including the compulsory question. The pattern of question paper should be 30% problem related, 10% thought provoking and 60% descriptive.

3. EVALUATION :

Evaluation of Practicals Subjects –

There shall be internal assessment component for practical courses having weightage of 20% of the allocated marks. It will be based on practical performance of the students in the laboratory, number of experiments performed, written report/record of the experiments and regularity (attendance) in the class.

The final end-semester Practical examination will be of 80% of the total marks and 4 (3+1) hours duration. The evaluation will be based on the following components:

(i) There will be written comprehensive test of 1 hour duration containing short answer questions and covering all the experiments. The test will have a weightage of 20% of the total allocated marks and will be jointly set by the teachers involved in the examination.

(ii) Performance in the allotted experiments done during the End-semester Practical examination (weightage - 25 %)

(iii) Viva voce by the external examiner (weightage - 20%) related to the practicals.

(iv) Continuous evaluation by the internal examiners based on the Viva Voce of the checked practicals (weightage - 15%).

4. PASSING CRITERIAN : The student has to obtain minimum of 40% marks to qualify a Course. The failing candidate has to reappear in end-semester examination. The grading system is detailed in a separate document “Regulations of the M.Sc. under the framework of Honours School System”.

Semester I (Credits = 20, Marks = 500)

Course	Subject	Marks	Credits	Teaching hrs./week
Core Courses (Compulsory)				
Core Course-1	PHE-MC1 Mathematical Physics -I	75	3	4 hrs.
Core Course-2	PHE-MC2 Classical Mechanics	75	3	4 hrs.
Core Course-3	PHE-MC3 Quantum Mechanics -I	75	3	4 hrs.
Core Course-4	PHE-MC4 Electronics -I	75	3	4 hrs.
Core Course-5	PHE-MC5 : Physics Laboratory PHE-MC5A: Practical Laboratory-II PHE-MC5B: Computer Laboratory-II	200 150 50	8 6 2	 9 hrs. 4 hrs.

Semester II (Credits = 20, Marks = 500)

Course	Subject	Marks	Credits	Teaching hrs./week
Core Courses (Compulsory)				
Core Course-6	PHE-MC6: Digital Electronics	75	3	4 hrs.
Core Course-7	PHE-MC7: Statistical Mechanics	75	3	4 hrs.
Core Course-8	PHE-MC8: Relativistic Quantum Mechanics and Quantum Field Theory	75	3	4 hrs.
Core Course-9	PHE-MC9: Classical Electrodynamics	75	3	4 hrs.
Core Course-10	PHE-MC10: Physics Laboratory PHE-MC10A: Practical Laboratory-II PHE-MC10B: Computer Laboratory-II	200 150 50	8 6 2	 9 hrs. 4 hrs.

M.Sc. (Hons. School) Physics (Specialization in Electronics) 1st Year
FIRST SEMESTER

PHE- MC1: MATHEMATICAL PHYSICS – I

Total Lectures: 45+15 = 60 **Credits: 03**

Max. Marks: 15+60= 75

Objective : The aim and objective of the course on **Mathematical Physics-I** is to equip the M.Sc. (H.S.) student with the mathematical techniques that he/she needs for understanding theoretical treatment in different courses taught in this class and for developing a strong background if he/she chooses to pursue research in physics as a career.

Note: (i) Some portions of the syllabus have already been covered in the undergraduate courses. The stress should be given on the application part.

(ii) The pattern of the question papers for the mid-term and end-semester examinations are given in the beginning of the syllabus.

I **Complex Variables** : Cauchy-Riemann conditions, analycity, Cauchy-Goursat theorem, Cauchy's Integral formula, branch points and branch cuts, multivalued functions, Taylor and Laurent expansion, singularities and convergence, calculus of residues, evaluation of definite integrals, Dispersion relation.

II **Tensors :** Tensors in index notation, Kronecker and Levi Civita tensors, inner and outer products, contraction, symmetric and antisymmetric tensors, quotient law, Noncartesian tensors, metric tensors, covariant and contravariant tensors, Covariant differentiation. Applications.

III **Delta and Gamma Functions :** Dirac delta function, Delta sequences for one dimensional function, properties of delta function, Gamma function, factorial notation and applications, Beta function.

IV **Differential Equations :** Partial differential equations of theoretical physics, boundary value, problems, Neumann & Dirichlet Boundary conditions, separation of variables, singular points, series solutions, second solution.

V Special Functions : Bessel functions of first and second kind, Generating function, integral representation and recurrence relations for Bessel's functions of first kind, orthogonality. Legendre functions : generating function, recurrence relations and special properties, orthogonality, various definitions of Legendre polynominals. Associated Legendre functions: recurrence relations, parity and orthogonality, Hermite functions, Laguerre functions.

TUTORIALS : Relevant problems given at the end of each section in Book 1.

Suggested Reading:

1. Mathematical Methods for Physicists : G. Arfken and H.J. Weber (Academic Press, San Diego) 7th edition, 2012.
2. Mathematical Physics : P.K. Chattopadhyay (Wiley Eastern, New Delhi), 2004.
3. Mathematical Methods in the Physical Sciences – M.L. Boas (Wiley, New York) 3rd edition, 2007.
4. Mathematical Methods for Physics and Engineering : K.F.Riley, M.P.Hobson and S.J. Bence (Cambridge University Press, Cambridge) 3rd ed., 2006.
5. Special Functions : E.D. Rainville (MacMillan, New York), 1960.

Additional Suggested Reading:

6. Mathematical Physics : A.K. Ghatak, I.C. Goyal and S.J. Chua (MacMillan, India, Delhi),1986.
7. Complex variables and applications, J.W. Brown, R.V. Churchill, 8th Ed., McGraw Hill (2009).
8. Introduction to Mathematical Physics, C. Harper, (PHI) 1978.

PHE- MC2 CLASSICAL MECHANICS

Total Lectures: 45+15 = 60 **Credits: 03**

Max. Marks: 15+60= 75

Objective : The aim and objective of the course on **Classical Mechanics** is to train the students of M.Sc. (H.S.) class in the Lagrangian and Hamiltonian formalisms to an extent that they can use these in the modern branches like Quantum Mechanics, quantum Field Theory, Condensed Matter Physics, Astrophysics etc.

Note: The pattern of the question papers for the mid-term and end-semester examinations are given in the beginning of the syllabus.

I **Lagrangian Formulation:** Mechanics of a system of particles; constraints of motion, generalized coordinates, D'Alembert's Principle and Lagrange's velocity - dependent forces and the dissipation function, Applications of Lagrangian formulation.

II **Hamilton's Principles:** Calculus of variations, Hamilton's principle, Lagrange's equation from Hamilton's principle, extension to nonholonomic systems, advantages of variational principle formulation, symmetry properties of space and time and conservation theorems.

III **Hamilton's Equations:** Legendre Transformation, Hamilton's equations of motion, Cyclic-co-ordinates, Hamilton's equations from variational principle, Principle of least action.

IV **Two-body central force problem**: Equivalent one body problem, Equation of motion and first integrals, Equivalent one dimensional problem, Classification of orbits, Differential equation for the orbit, Kepler's problem. Differential & total scattering cross-section, Scattering by inverse square law, Rutherford's formula.

V **Canonical Transformation and Hamilton-Jacobi Theory:** Canonical transformation and its examples, Poisson's brackets, Equations of motion, Angular momentum, Poisson's Bracket relations, infinitesimal canonical transformation, Conservation Theorems. Hamilton-Jacobi equations for principal and characteristic functions, Harmonic oscillator problem,

VI **Rigid Body Motion:** Independent co-ordinates of rigid body, orthogonal transformations, Eulerian Angles and Euler's theorem, infinitesimal rotation, Rate of change of a vector, Coriolis force, angular momentum and kinetic energy of a rigid body, the inertia tensor.

VII **Small Oscillations:** Eigen value equation, Free vibrations, Normal Coordinates, Vibrations of a triatomic molecule.

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

Suggested Reading:

1. Classical Mechanics: H. Goldstein, C.Poole and J.Safko (Pearson Education Asia, New Delhi), 3rd ed 2002.
2. Classical Mechanics of Particles and Rigid Bodies: K.C. Gupta (Wiley Eastern, New Delhi), 1988.

PHE – MC3 QUANTUM MECHANICS

Total Lectures: 45+15 = 60 **Credits: 03**
Max. Marks: 15+60= 75

Objective : The aim and objective of the course on **Quantum Mechanics** is to introduce the students of M.Sc. (H.S.) class to the formal structure of the subject and to equip them with the techniques of angular momentum, perturbation theory and scattering theory so that they can use these in various branches of physics as per their requirement.

Note: The pattern of the question papers for the mid-term and end-semester examinations are given in the beginning of the syllabus.

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. Density Matrix and Mixed Ensemble.

II Angular Momentum : Angular part of the Schrödinger equation for a spherically symmetric potential, orbital angular momentum operator. Eigenvalues and eigenvectors of L^2 and Lz. Spin angular momentum, General angular momentum, Eigenvalues and eigenvectors of J^2 and Jz.
Representation of general angular momentum operator, Addition of angular momenta, C.G. co-efficients. Wigner-Eckart theorem and its applications. Symmetries, conservation laws, degeneracies

III Stationary State Approximate Methods: Non-Degenerate and degenerate perturbation theory and its applications, Variational method with applications to the ground states of harmonic oscillator and other sample systems.

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.

V Scattering Theory : Scattering Cross-section and scattering amplitude, partial wave analysis, Low energy scattering, Green's functions in scattering theory, Born approximation and its application to Yukawa potential and other simple potentials. Optical theorem, Scattering of identical particles.

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

Suggested Reading:

1. Modern Quantum Mechanics : J.J. Sakurai (Addison Wesley, Reading), 2004.
2. Quantum Mechanics : E. Merzbacher (John Wiley, Singapore), 2004
3. Quantum Mechanics : M.P. Khanna, (Har Anand, New Delhi), 2006.
4. A Text book of Quantum Mechanics, P.M. Mathews and K. Venkatesan (Tata McGraw Hill, New Delhi) 2nd edition, 2004

Additional suggested Reading:

5. Quantum Mechanics : J.L. Powell and B. Crasemann (Narosa, New Delhi), 1995.
6. Quantum Physics : S. Gasiorowicz (Wiley, New York), 3rd ed. 2003.

PHE – MC4 ELECTRONICS-I

Total Lectures: 45+15 = 60 **Credits: 03**

Max. Marks: 15+60= 75

Objective : The **Electronics-I** course covers semiconductor physics, physical principles of devices and their basic applications, basic circuit analysis, first-order nonlinear circuits, Analysis of Passive and Active filters, OPAMP based analog circuits and introduction to various communication techniques.

Note: The pattern of the question papers for the mid-term and end-semester examinations are given in the beginning of the syllabus.

I Circuit Analysis : Lumped circuits, Non-linear resistors-series and parallel connections, D.C. operating point, small signal analysis, Thevenin and Norton theorems, Mesh and Node analysis. Admittance,impedance, hybrid and Transmission matrices for two and three-port networks and their applications.

First-order nonlinear circuits, Dynamic route, jump phenomenon and relaxation oscillator, triggering of bistable circuits.

Relation between time and frequency domains (Laplace transforms), Transfer function, Location of poles and zeros of response functions of active and passive systems (Nodal and modified nodal analysis), pole-zero cancellation, Sinusoidal frequency and phase response, Bode plot, Analysis of passive circuits/filters, Phase distortion and and equalizers, Transformer - equivalent circuit and transfer function, Autotransformer.

II Semiconductor Devices and applications: Direct and indirect semiconductors, Drift and diffusion of carriers, Photoconductors, Energy band diagrams, Semiconductor junctions, Metal-semiconductor junctions - Ohmic and rectifying contacts, Capacitance of p-n junctions, Varactors, Zener diode, Regulated power supplies, Schottky diode, switching diodes, Tunnel diode, Light emitting diodes, Semiconductor laser, Photodiodes, Solar cell, UJT, Gunn diode, IMPATT devices, pnpn devices and applications, Liquid crystal displays, MOSFET, Enhancement and depletion mode, FET as switch and amplifier configurations.

III Analog Circuits : Differential amplifiers, common mode rejection ratio, Transfer characteristics, OPAMP configurations, open loop and close loop gain, inverting, non-inverting and differential amplifier, Basic characteristics with detailed internal circuit of IC Opamp, slew rate, Comparators with hysteresis, Window comparator, wave generators, Summing amplifier, Analogue computation, Logarithmic and anti-logarithmic amplifiers, Current-to-voltage and Voltage-to-current converter, Voltage regulation circuits, Gyrator, Precision rectifiers, Instrumentation amplifiers, True RMS voltage measurements. 555 timer based circuits.

Electronic circuits - Phase shift oscillator, Wien-bridge oscillator, Sample and hold circuits, Phase Locking Loop basics and applications. Lock-in-detector, box-car integrator.

Filters - Sallen and Key configuration and Multifeedback configuration, LP, HP, BP and BR active filters, Delay equalizers.

IV Communication: Microwaves, Satellite communication, Elements of Digital Communication Systems, Carrier systems ASK, FSK, PSK and DPSK, M-ary Communication, Scrambling

TUTORIALS : Relevant problems given in the recommended books.

Suggested Reading:

1. Solid State Electronic Devices: Ben Streetman, Sanjay Banerjee (Prentice Hall India) 6th Edition, 2005.
2. Electronic Principles : A.P. Malvino (Tata McGraw, New Delhi), 7th edition, 2009.

3. Linear and Non-linear Circuits : Chua, Desoer and Kuh (Tata McGraw), 1987.
4. Applications of Laplace Transforms : Leonard R. Geis (Prentice Hall, New Jersey), 1989.
5. Circuit theory Fundamentals and Applications : Aram Budak (Prentice-Hall) 1987.
6. Integrated Electronics : Millman and Halkias (Tata McGraw Hill) 1991.
7. Operational amplifiers and Linear Integrated circuits, R.F. Coughlin and F.F. Driscoll, (Prentice Hall of India, New Delhi), 2000.

Additional suggested Reading:

9. Semiconductor Devices - Physics and Technology : S.M. Sze (John Wiley), 2002.
10. Electronic Devices and Circuits Theory : Boylested and Nashelsky, (Pearson Education) 10th ed. 2009.
11. OPAMPS and Linear Integrated circuits : Ramakant A Gayakwad (Prentice Hall), 1992.

PHE – MC5 PHYSICS LABORATORY I

PHE – MC5A PRACTICAL LABORATORY I

Total Lectures: 135 hours **Credits: 06**

Max. Marks: 30+120= 150

Objective : *The aim and objective of the course on* ***Physics Practical Laboratory I*** *is to expose the students of M.Sc. (H.S.) class to experimental techniques in general physics, electronics, nuclear physics and condensed matter physics so that they can verify some of the things read in theory here or in earlier classes and develop confidence to handle sophisticated equipment. The project work on Physics/Electronics topics, Industrial visit, Seminar on Advanced techniques in Physics will further enhance subject, presentation and entrepreneurship skills.*

Note:

(i) Students are expected to perform at least 10 experiments from Units 1-7 in each semester. The students with Specialization in Electronics will perform more experiments from Unit 2. The experiments performed in first semester cannot be repeated in second Semester. This part will carry 125 (25+100) marks.

(ii) Each student will be assigned a project work/Industrial visit and give seminar on Advanced *techniques in Physics/Electronics* during first year. The student will complete units 8 and 9 taking one in each semester. This part will carry 25 (5+20) marks.

(iii) The evaluation procedure for the Practical examination is given in the beginning of the syllabus.

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, Digital storage oscilloscope, Multimeter, Wave-form generator. Experience in electronics & mechanical workshops.

Unit 2 : Analog and Digital electronics

1. To study the power dissipation in the SSB and DSB side bands of AM wave.To study the demodulation of AM wave.
2. To study various aspects of frequency modulation and demodulation.
3. To study the frequency response of an operational amplifier & to use operational amplifier for different mathematical operations.
4. To study the characteristics of a regulated power supply and voltage multiplier circuits.
5. To design a rectangular/triangular waveform generator using Comparators and IC8038.
6. To study Hartley and Wien-Bridge oscillators.
7. UJT characteristics and its application as relaxation oscillator or triggering of triac.
8. Hybrid parameters of a transistor and design an amplifier. Determination of k/e ratio.
9. FET/MOSFET characteristics, biasing and its applications as an amplifier.
10. To design (i) Low pass filter (ii) High pass filter (iii) All-pass filter (iv) Band pass filter (v) Band-reject passive filter.
11. To study logic gates and flip flop circuits using on a bread-board.
12. To configure various shift registers and digital counters. Configure seven segment displays and drivers.
13. Use of timer IC 555 in astable and monostable modes and applications involving relays, LDR.

Unit 3 : Material science

17. To study temperature-dependence of conductivity of a given semiconductor crystal using four probe method.
18. To determine the Hall coefficient for a given semi-conductor.
19. To determine dipole moment of an organic molecule, Acetone.
20. To study the lattice dynamics using LC analog kit.
21. To study the characteristic of J-H curve using ferromagnetic standards.

22. To determine the velocity of ultrasonic waves using interferometer as a function of temperature.
23. Temperature dependence of a ceramic capacitor - Verification of Curie-Weiss law for the electrical susceptibility of a ferroelectric material.
24. To determine Percolation threshold and temperature dependence of resistance in composites.
25. Tracking of the Ferromagnetic-paramagnetic transition in Nickel through electrical resistivity.
26. To study the characteristics of a PN junction with varying temperature & the capacitance of the junction.
27. To study the characteristics of a LED and determine activation energy.
28. Measurement of vacuum using the pirani/thermocouple gauge.
29. (i) Study of the characteristics of klystron tube and to determine its electronic tuning range; (ii) To determine the standing wave ratio and reflection coefficient; (iii) To determine the frequency & wavelength in a rectangular waveguide working on TE10 mode; (iv) To study the square law behaviour of a microwave crystal detector.

Unit 4 : Nuclear Radiation detectors and measurement techniques

30. To study the characteristics and dead time of a GM Counter.
31. To study Poisson and Gaussian distributions using a GM Counter.
32. To study the alpha spectrum from natural sources Th and U.
33. To determine the gamma-ray absorption coefficient for different elements.
34. To study absorption of beta rays in Al and deduce end-point energy of a beta emitter.
35. To calibrate the given gamma-ray spectrometer and determine its energy resolution.

Unit 5 : Optics

35. Laboratory spectroscopy of standard lamps
36. Stellar spectroscopy
37. To study the Kerr effect using Nitrobenzene
38. To study polarization by reflection - Determination of Brewester's angle.
39. To measure numerical aperture and propagation loss and bending losses for optical fibre as function of bending angle and at various wavelengths.
40. To study the Magnetorestriction effect using Michelson interferometer.

Unit 6 : Fundamental constants in Physics

14. To determine Planck's constant using photocell.
15. To determine the electric charge of an electron using Millikan drop experiment.

16. To determine the Hubble's constant (expansion rate of universe) using astronomical data and deduce the large scale structure of the universe.

Unit 7 : Mechanics

42. To study the potential energy curve of the magnet-magnet interaction using air-track setup along with the simple experiments in mechanics.
43. To estimate the rotational period of sun using sunspots observations.
44. To estimate the mass of Jupiter using rotational periods of Galilean satellites.
45. To estimate the distance between sun and earth (1AU) using GONG project results of Venus and Mercury transits.

Unit 8 : Industrial visit

The student will visit an Electronics Industry/Scientific Equipment Industry/National Laboratory of his own and submit a report of about 20 pages about the visit (typed on both the sides of the paper and properly bound) by a date to be announced by the PGAPMEC. The emphasis should be on Electronics or Semiconductor. The student will be evaluated through presentation and viva-voce.

Unit 9 : Project work

The aim of project work in M.Sc.(H.S.) 1st/2nd semesters is to expose the students to development/improve measurement procedure of a laboratory experiment, fabrication of a device/electronics circuit, Understanding and handling of Physics-based analytical techniques. A student will work of his/her own, however, he/she will report the progress of the project to an assigned teacher. A report of about 20 pages about the work done in the project (typed on both the sides of the paper and properly bound) will be submitted by a date to be announced by the PGAPMEC. The student will be evaluated through presentation and viva-voce.

PHE – MC5B COMPUTATIONAL PHYSICS I

Total Lectures: 10 Theory + 35 hours
Credits: 02

Max. Marks: 10+40= 50

Objective : The aim and objective of the course on **Computational Physics I** is to familiarize the of M.Sc. (H.S.) students with the numerical methods used in computation and programming using C++/FORTRAN 90 language so that they can use these in solving simple problems pertaining to Physics.

Note : The Computational Physics paper will consist of two parts –
(i) Written examination for 50% of the total marks covering Unit I and Unit II with equal weightage and duration one hour.
(ii) Practical examination for 50% of the total marks and duration two hours.

Unit I

Introduction to Digital Computers, Computer hardware, Operating Systems - Linux, Windows
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.
Functions :- Standard Library Functions and User-defined Functions. Void Functions and Functions returning Values.
Idea of Classes, Objects, Idea of Strings and Pointers.

OR

Introduction to Digital Computers, Computer hardware, Operating Systems - Linux, Windows

Fortran 90 Language: Intrinsic Functions, Data Types, Constants, and Variables, Double Precision, Operation and Intrinsic Functions, Expressions and Assignment Statements, Format-Directed Input and Output.Program Structure, Logical Operators and Logical Expression, If Constructs - Block If, Logical If, Arithmetic IF Statements, GOTO statement, The Case Construct, Do Loops

Programming Units: Main Program, File operation for input and output data. Single and Multidimensional Arrays, Data Statement, Common and Equivalence Statements, Modules,Functions and Subroutines.

Unit II

Programs (**C++ using "Classes")** based on the basic numerical methods:

Statistics : Measures of central moment, correlation coefficients.

Interpolations - Least squares fitting, Lagrange interpolation.

Numerical differentiation, Numerical integration;

Numerical solution of differential equations by Euler, predictor-corrector and Runge-Kutta methods, problems.

Matrices, addition, multiplication, determinant, eigenvalues and eigenvectors, inversion, solution of simultaneous equations.

Random number generators, Simulation using Monte Carlo techniques

Suggested Reading:

1. Numerical Mathematical Analysis, J.B. Scarborough (Oxford & IBH Book Co.) 6th ed., 1979.
2. A first course in Computational Physics: P.L. DeVries (Wiley) 2nd edition, 2011.
3. Computer Applications in Physics: S. Chandra (Narosa) 2nd edition, 2005.
4. Computational Physics: R.C. Verma, P.K. Ahluwalia and K.C. Sharma (New Age) 2000.
5. Object Oriented Programming with C++: Balagurusamy, (Tata McGrawHill) 4th edition 2008.
6. Schaum's Outline of Programming with Fortran 77
7. Schaum's Outline of Programming with Fortran 90
8. Computer Programming in Fortran 90 and 95, V. RajaRaman, PHI Learning Pvt. Ltd.

M.Sc. (Hons. School) Physics (Specialization in Electronics) 1st Year

SECOND SEMESTER

PHE – MC6 ELECTRONICS-II DIGITAL ELECTRONICS

Total Lectures: 45+15 = 60 **Credits: 03**

Max. Marks: 15+60= 75

Note: The pattern of the question papers for the mid-term and end-semester examinations are given in the beginning of the syllabus.

I. Number systems and codes, Boolean algebra, representation of negative numbers, one's and two's complement, binary addition, subtraction, multiplication and division.

II. Digital logic families : TTL, ECL, CMOS, - switching and propagation delay, fan out and fan in, TTL-CMOS and CMOS-TTL interfaces. Tri-state logic.

III. Combinational logic design : de Morgans theorem, Karnaugh maps.
Progrmmable Logic Arrays, Programmable array logic devices, CPLDs
Encoders, Decoders, Three-state devices, Multiplexers, Demultiplexers, Arithmetic building blocks, Parity generators.
Adders, Subtractors and ALUs.
Hardware description languages : VHDL-based design flow, Program structure, functions and procedure, sequential logic design.

IV. Sequential logic circuits : Flip-Flops – RS, JK, D, T, clocked, preset and clear operation, race-around conditions in JK Flip-flops, master-slave JK flip-flops, Switch contact bounce circuit.

Clocked synchronous state-machine analysis : State-machine structure, output logic, characteristic equations, analysis of state-machines with D flip-flops.

Sequential logic design : Standards, state-machine descriptions, timing diagrams. Mealy and Moore machines,Shift registers, Asynchronous and Synchronous counters, design, Sequential PLDs.

V. A/D Converters : Successive approximation, Counter-type, Dual slope, voltage to frequency and voltage to time conversion techniques, accuracy and resolution. Use with sample-and-hold circuits.
D/A converter using resistive network, accuracy and resolution.

VI Memory, CPLDs and FPGAs :

Semiconductor Memories : ROM, PROM and EPROM, RAM, Static and Dynamic Random Access Memories (SRAM and DRAM), content addressable memory, Other advanced memories.

Complex Programmable Logic Devices - *Xilinx XC9500* CPLD family, Function-Block and I/O Architecture.

Field programmable Gate Arrays - *Xilinx XC4000* FPGA family, configurable logic block, I/O block.

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

Suggested Reading:

1. Digital Design : Priciples and Practices, John F. Wakerly, 4^{th} Ed. (Pearson, Prentice Hall) 2006.
2. Digital Principles and Applications by Malvino and Leach (Tata McGraw Hill), 2010.
3. Microelectronics by Millman and Grabel (Tata McGraw Hill), 1999.
4. A text book of Digital Electronics, R.S. Sedha (S. Chand Publishers), 2004.
5. Integrated Electronics by Millman and Halkias (Tata McGraw Hill), 2010.
6. Semiconductor Devices : Physics and Technology by S.M. Sze (John Wiley), 2007.
7. Digital Computer Electronics : Albert P. Malvino, Jerald A Brown (Tata-McGraw Hill) 3^{rd} ed. 2004.

PHE – MC7 STATISTICAL MECHANICS

Total Lectures: 45+15 = 60 **Credits: 03**

Max. Marks: 15+60= 75

Objective *: The aim and objective of the course on* ***Statistical Mechanics*** *is to equip the M.Sc. (H.S.) student with the techniques of Ensemble theory so that he/she can use these to understand the macroscopic properties of the matter in bulk in terms of its microscopic constituents.*

Note: The pattern of the question papers for the mid-term and end-semester examinations are given in the beginning of the syllabus.

I The Statistical Basis of Thermodynamics: The macroscopic and microscopic states, contact between statistics and thermodynamics, classical ideal gas, Gibbs paradox and its solution.

II Ensemble Theory: Phase space and Liouville's theorem, the microcanonical ensemble theory and its application to ideal gas of monatomic particles; The canonical ensemble and its thermodynamics, partition function, classical ideal gas in canonical ensemble theory, energy fluctuations, equipartition and virial theorems, a system of quantum harmonic oscillators as canonical ensemble, statistics of paramagnetism; The grand canonical ensemble and significance of statistical quantities, classical ideal gas in grand canonical ensemble theory, density and energy fluctuations.

III Quantum Statistics of Ideal Systems: Quantum states and phase space, an ideal gas in quantum mechanical ensembles, statistics of occupation numbers; 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 (the Debye field); Ideal Fermi systems: thermodynamic behaviour of an ideal Fermi gas, discussion of heat capacity of a free-electron gas at low temperatures, Pauli paramagnetism.

IV Elements of Phase Transitions: First- and second-order phase transitions, diamagnetism, paramegnetism, and ferromagnetism, a dynamical model of phase transitions, Ising and Heisenberg models.

V Fluctuations: Thermodynamic fluctuations, random walk and Brownian motion, introduction to nonequilibrium processes, diffusion equation.

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

Suggested Reading:

1. Statistical Mechanics: R.K. Pathria and P.D. Beale (Butterworth-Heinemann, Oxford), 3rd edition, 2011.
2. Statistical Mechanics: K. Huang (Wiley Eastern, New Delhi), 1987.

Additional suggested Reading:

3. Statistical Mechanics: B.K. Agarwal and M. Eisner (Wiley Eastern, New Delhi) 2nd edition, 2011.
4. Elementary Statistical Physics: C. Kittel (Wiley, New York), 2004.
5. Statistical Mechanics: S.K. Sinha (Tata McGraw Hill, New Delhi), 1990.

PHE-MC8 : RELATIVISTIC QUANTUM MECHANICS AND QUANTUM FIELD THEORY

Total Lectures: 45+15 = 60 **Credits: 03**

Max. Marks: 15+60= 75

Objective : *The aim and objective of the course on **Relativistic Quantum Mechanics and Quantum Field Theory** is to introduce the M.Sc. (H.S.) student to the formal structure of the subject and to equip him/her with the techniques of quantum field theory so that he/she can use these in various branches of physics as per his/her requirement.*

Note: The pattern of the question papers for the mid-term and end-semester examinations are given in the beginning of the syllabus.

I **Relativistic Quantum Mechanics** : Klein-Gordon equation, Dirac equation and its plane wave solutions, significance of negative energy solutions, spin angular momentum of the Dirac particle. The nonrelativistic limit of Dirac equation, Electron in electromagnetic fields, spin magnetic moment , spin-orbit interaction, Dirac equation for a particle in a central field, fine structure of hydrogen atom, Lambshift.

II **Quantum Field Theory** : Resume of Lagrangian and Hamiltonian formalism of a classical field, Noether theorem. Quantization of real scalar field, complex scalar field, Dirac field and e.m. field, Covariant perturbation theory, Wick's Theorem, S-matrix, Feynman rules, Feynman diagrams and their applications, Yukawa field theory, calculation of scattering cross sections, decay rates, with examples. Quantum Electrodynamics, calculation of matrix elements - for first order and second order processes.

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

Suggested Reading:

1. A first book of Quantum Field Theory, A. Lahiri & P. Pal, (Narosa Publishers, New Delhi), 2nd ed. 2005.
2. Lectures on Quantum Field Theory, A. Das (World Scientific), 2008.
3. A Text book of Quantum Mechanics, P.M. Mathews and K. Venkatesan, (Tata McGraw Hill, New Delhi), 2004.
4. Quantum Mechanics : M.P. Khanna, (Har Anand, New Delhi), 2006.

Additional suggested Reading:

5. Quantum Field Theory : H. Mandl and G. Shaw, (Wiley, New York) 2010.
6. Advanced Quantum Mechanics : J.J. Sakurai (Addison-Wesley, Reading), 2004.

PHE - MC9 CLASSICAL ELECTRODYNAMICS

Total Lectures: 45+15 = 60 **Credits: 03**

Max. Marks: 15+60= 75

Objective: The **Classical Electrodynamics** course covers Electrostatics and Magnetostatics including Boundary value problems, Maxwell equations and their applications to propagation of electromagnetic waves in dielectrics, metals and plasma media; EM waves in bounded media, waveguides, Radiation from time varying sources. It also covers motions of relativistic and non-relativistic charged particles in electrostatic and magnetic fields.

Note: The pattern of the question papers for the mid-term and end-semester examinations are given in the beginning of the syllabus.

I. Electrostatics: Gauss's law, Poisson and Laplace equation, Green's theorem, Dirichlet and Neuman boundary conditions, Formal solution of electrostatic boundary value problems with Green function, Electrostatic potential energy and energy density.

II. Boundary value problems in electrostatics: Method of Images , Point Charge in the Presence of a Grounded Conducting Sphere, Point Charge in the Presence of a Charged, Insulated, Conducting Sphere, Point Charge Near a Conducting Sphere at Fixed Potential , Conducting Sphere in a Uniform Electric Field by Method of Images, Green Function for the Sphere; General Solution for the Potential , Conducting Sphere with Hemispheres at Different Potentials, Separation of Variables; Laplace Equation in Rectangular coordinates, Laplace Equation in Spherical Coordinates, Legendre Equation and Legendre Polynomials, Boundary-Value Problems with Azimuthal Symmetry, Associated Legendre Functions and the Spherical Harmonics $Y_{lm}(\theta, \Phi)$.

III. Mutipole and dielectrics: Multipole Expansion, Multipole Expansion of the Energy of a Charge Distribution in an External Field, Elementary Treatment of Electrostatics with Ponderable Media, Boundary-Value Problems with Dielectrics, Electrostatic energy in dielectric media.

IV. Magnetostatics: Biot and Savart Law, Ampere's Law, Vector potential, Magnetic Fields of a Localized Current Distribution, Magnetic Moment , Force and Torque on and Energy of a Localized Current Distribution in an External Magnetic Induction, Singularity in dipole field, Fermi-contact term, Macroscopic Equations, Boundary Conditions on B and H, Methods of Solving Boundary-Value Problems in Magnetostatics, Uniformly Magnetized Sphere, Magnetized Sphere in an External

Field; Permanent Magnets, Magnetic Shielding, Spherical Shell of Permeable Material in a Uniform Field

V. Maxwell Equation and Plane electromagnetic waves: Maxwell's Displacement Current; Maxwell Equations, Vector and Scalar Potentials, Gauge Transformations, Lorenz Gauge, Coulomb Gauge, Hertz potential, Green Functions for the Wave Equation, plane waves in free space and isotropic dielectrics, waves in conducting media, skin depth, Plane waves in a non conducting medium, Reflection and Refraction of Electromagnetic Waves at a Plane Interface Between two Dielectrics, Fresnel’s amplitude relations, Reflection and Transmission coefficients, polarization by reflection, Brewster’s angle, Total internal reflection, Stoke’s parameters, Waves in rarefied plasma (ionosphere) and cold magneto-plasma, Frequency Dispersion Characteristics of Dielectrics, Conductors, and Plasmas, Simplified Model of Propagation in the Ionosphere and Magnetosphere

VI. Wave guides and resonant cavities: Fields at the Surface of and within a Conductor, Cylindrical Cavities and Waveguides, Waveguides, Modes in a Rectangular Waveguide, Energy Flow and Attenuation in Waveguides, Coaxial cable, Resonant Cavities, Power Losses in a Cavity; Q of a Cavity , Earth and Ionosphere as a Resonant Cavity: Schumann Resonances, Multimode Propagation in Optical Fibers, Modes in Dielectric Waveguides

VII. Radiating systems, Multipole fields and Radiations: Fields and Radiation of a Localized Oscillating Source, Electric Dipole Fields and Radiation, Magnetic Dipole and Electric Quadrupole Fields, Center-Fed Linear Antenna, Multipole Expansion of the Electromagnetic Fields, Angular Distribution of Multipole Radiation. Sources of multipole radiation, mutipole radiations in atoms and nuclei.

VIII. **Charged Particle Dynamics:** Non-relativistic motion in uniform constant fields, Slowly varying magnetic field : Time varying magnetic field, space varying magnetisc field, Adiabatic invariance of flux through an orbit, magnetic mirroring, Crossed electrostatic and magnetic fields and applications, Relativistic motion of a charged particle in electrostatic and magnetic fields.

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

Suggested Reading:

1. Classical Electrodynamics : J.D. Jackson, (New Age, New Delhi) 2009.
2. Introduction to Electrodynamics: D.J. Griffiths (Prentice Hall India, New Delhi) 4th ed., 2012.
3. Classical Electrodynamics : S.P. Puri (Narosa Publishing House) 2011.

Additional suggested Reading:

4. Electromagnetic Fields, Ronald K. Wangsness (John Wiley and Sons) 2nd edition,1986.
5. Electromagnetic Field Theory Fundamentals : Bhag Singh Guru and H.R. Hiziroglu (Cambridge University Press) 2nd edition, 2004.
6. Introduction to Electrodynamics : A.Z. Capri and P.V. Panat (Narosa Publishing House) 2010.
7. Classical Electromagnetic Radiation : J.B. Marion and M.A. Heald, (Saunders College Publishing House) 3rd edition, 1995.

PHE – MC10 PHYSICS LABORATORY II

PHE – MC10A PRACTICAL LABORATORY II

Total Lectures: 135 hours **Credits: 06**

Max. Marks: 30+120= 150

Objective : *The aim and objective of the course on* ***Physics Practical Laboratory II*** *is to expose the students of M.Sc. (H.S.) class to experimental techniques in general physics, electronics, nuclear physics and condensed matter physics so that they can verify some of the things read in theory here or in earlier classes and develop confidence to handle sophisticated equipment. The project work on Physics/Electronics topics, Industrial visit, Seminar on Advanced techniques in Physics will further enhance subject, presentation and entrepreneurship skills.*

Note:

(i) Students are expected to perform at least 10 experiments from Units 1-7 in each semester. The experiments performed in first semester cannot be repeated in second Semester. This part will carry 125 (25+100) marks.

(ii) Each student will be assigned a project work/Industrial visit and give seminar on Advanced *techniques in Physics/Electronics* during first year. The student will complete units 8 and 9 taking one in each semester. This part will carry 25 (5+20) marks.

(iii) The evaluation procedure for the Practical examination is given in the beginning of the syllabus.

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, Digital storage oscilloscope, Multimeter, Wave-form generator. Experience in electronics & mechanical workshops.

Unit 2 : Analog and Digital electronics

1. To study the power dissipation in the SSB and DSB side bands of AM wave.To study the demodulation of AM wave.
2. To study various aspects of frequency modulation and demodulation.
3. To study the frequency response of an operational amplifier & to use operational amplifier for different mathematical operations.
4. To study the characteristics of a regulated power supply and voltage multiplier circuits.
5. To design a rectangular/triangular waveform generator using Comparators and IC8038.
6. To study Hartley and Wien-Bridge oscillators.
7. UJT characteristics and its application as relaxation oscillator or triggering of triac.
8. Hybrid parameters of a transistor and design an amplifier. Determination of k/e ratio.
9. FET/MOSFET characteristics, biasing and its applications as an amplifier.
10. To design (i) Low pass filter (ii) High pass filter (iii) All-pass filter (iv) Band pass filter (v) Band-reject passive filter.
11. To study logic gates and flip flop circuits using on a bread-board.
12. To configure various shift registers and digital counters. Configure seven segment displays and drivers.
13. Use of timer IC 555 in astable and monostable modes and applications involving relays, LDR.

Unit 3 : Material science

17. To study temperature-dependence of conductivity of a given semiconductor crystal using four probe method.
18. To determine the Hall coefficient for a given semi-conductor.
19. To determine dipole moment of an organic molecule, Acetone.
20. To study the lattice dynamics using LC analog kit.
21. To study the characteristic of J-H curve using ferromagnetic standards.
22. To determine the velocity of ultrasonic waves using interferometer as a function of temperature.

23. Temperature dependence of a ceramic capacitor - Verification of Curie-Weiss law for the electrical susceptibility of a ferroelectric material.
24. To determine Percolation threshold and temperature dependence of resistance in composites.
25. Tracking of the Ferromagnetic-paramagnetic transition in Nickel through electrical resistivity.
26. To study the characteristics of a PN junction with varying temperature & the capacitance of the junction.
27. To study the characteristics of a LED and determine activation energy.
28. Measurement of vacuum using the pirani/thermocouple gauge.
29. (i) Study of the characteristics of klystron tube and to determine its electronic tuning range; (ii) To determine the standing wave ratio and reflection coefficient; (iii) To determine the frequency & wavelength in a rectangular waveguide working on TE10 mode; (iv) To study the square law behaviour of a microwave crystal detector.

Unit 4 : Nuclear Radiation detectors and measurement techniques

30. To study the characteristics and dead time of a GM Counter.
31. To study Poisson and Gaussian distributions using a GM Counter.
32. To study the alpha spectrum from natural sources Th and U.
33. To determine the gamma-ray absorption coefficient for different elements.
34. To study absorption of beta rays in Al and deduce end-point energy of a beta emitter.
35. To calibrate the given gamma-ray spectrometer and determine its energy resolution.

Unit 5 : Optics

35. Laboratory spectroscopy of standard lamps
36. Stellar spectroscopy
37. To study the Kerr effect using Nitrobenzene
38. To study polarization by reflection - Determination of Brewester’s angle.
39. To measure numerical aperture and propagation loss and bending losses for optical fibre as function of bending angle and at various wavelengths.
40. To study the Magnetorestriction effect using Michelson interferometer.

Unit 6 : Fundamental constants in Physics

14. To determine Planck’s constant using photocell.
15. To determine the electric charge of an electron using Millikan drop experiment.

16. To determine the Hubble's constant (expansion rate of universe) using astronomical data and deduce the large scale structure of the universe.

Unit 7 : Mechanics

42. To study the potential energy curve of the magnet-magnet interaction using air-track setup along with the simple experiments in mechanics.
43. To estimate the rotational period of sun using sunspots observations.
44. To estimate the mass of Jupiter using rotational periods of Galilean satellites.
45. To estimate the distance between sun and earth (1AU) using GONG project results of Venus and Mercury transits.

Unit 8 : Industrial visit

The student will visit an Industry/National Laboratory of his own and submit a report of about 20 pages about the visit (typed on both the sides of the paper and properly bound) by a date to be announced by the PGAPMEC. The student will be evaluated through presentation and viva-voce.

Unit 9 : Project work

The aim of project work in M.Sc.(H.S.) 1st/2nd semesters is to expose the students to development/improve measurement procedure of a laboratory experiment, fabrication of a device/electronics circuit, Understanding and handling of Physics-based analytical techniques. A student will work of his/her own, however, he/she will report the progress of the project to an assigned teacher. A report of about 20 pages about the work done in the project (typed on both the sides of the paper and properly bound) will be submitted by a date to be announced by the PGAPMEC. The student will be evaluated through presentation and viva-voce.

PHE – MC10B COMPUTATIONAL PHYSICS II

Total Lectures: 45 **Credits: 02**

Max. Marks: 15+60= 75

Objective :The aim and objective of the course on **Computational Physics II** is to train the students of M.Sc. (H.S.) class in the usage of C++/FORTRAN language for simulation of results for different physics problems so that they are well equipped in the use of computer for solving physics related problems.

Note :

(i) The student will perform either an assigned Project work (UNIT I) or the problems given in UNIT II.

(ii) In case of assigned project (UNIT I), the student will be evaluated through viva-voce (25 marks). In the final examination, the student will be asked to write a programme to check his Computer language skills (25 marks).

UNIT I

Project work:

The aim of project work on Computational Physics in M.Sc.(H.S.) 2nd semesters is to expose the students to computational techniques used for handling Physics problems. The student will work of his/her own, however, he/she will report the progress of the project to the teacher who has been assigned/suggested the Project problem. The problems are expected tpo be based on common numerica;l techniques which are used in different theoretical/experimental aspects of Physics.

OR

FORTRAN 90 programmes OR C++ Inheritance, Use of external scientific libraries in C++ programmes.

List of Physics Problems:

1. Write a program to study graphically the EM oscillations in a LCR circuit (use Runge-Kutta Method). Show the variation of (i) Charge vs Time and (ii) Current vs Time.
2. Study graphically the motion of falling spherical body under various effects of medium (viscous drag, buoyancy and air drag) using Euler method.
3. Study graphically the path of a projectile with and without air drag using FN method. Find the horizontal and maximum height in either case. Write your comments on the findings.
4. Study the motion of an artificial satellite.
5. Study the motion of (a) 1-D harmonic oscillator (without and with damping effects). (b) two coupled harmonic oscillators. Draw graphs showing the relations:

i. Velocity vs Time

ii. Acceleration vs Time

iii. Position vs Time, also compare the numerical and analytical results.

6. To obtain the energy eigenvalues of a quantum oscillator using the Runge-Kutta method.
7. Study the motion of a charged particle in: (a) Uniform electric field, (b) Uniform Magnetic field, (c) in combined uniform electric and magnetic fields. Draw graphs in each case.
8. Use Monte Carlo techniques to simulate phenomenon of

   (i) Nuclear Radioactivity. Do the cases in which the daughter nuclei are also unstable with half life greater/lesser than the parent nucleus.

   (ii) to determine solid angle in a given geometry.

   (iii) simulate attenuation of gamma rays/neutron in an absorber and

   (iv) solve multiple integrals and compare results with Simpson's method.
9. To study phase trajectory of a Chaotic Pendulum.
10. To study convection in fluids using Lorenz system.

Suggested Reading:

1. Numerical Recipes in C++ The Art of Scientific Computing, William H. Press, Saul A. Teukolsky, William T. Vetterling and Brian P. Flannery, (Cambridge), 2nd ed. 2002.
2. A First Course in Computational Physics: P.L. DeVries (John Wiley) 2000.
3. An introduction to Computational Physics: Tao Pang (Cambridge), 2nd ed. 2006.
4. Computer Applications in Physics: S. Chandra (Narosa), 2006.
5. Computational Physics: R.C. Verma, P.K.Ahluwalia and K.C. Sharma (New Age), 2005.
6. Object Oriented Programming with C++: Balagurusamy, (Tata McGrawHill), 5th ed. 2011.
7. Schaum's Outline of Programming with Fortran 77
8. Schaum's Outline of Programming with Fortran 90
9. Computer Programming in Fortran 90 and 95, V. RajaRaman, PHI Learning Pvt. Ltd.

Semester III (Credits = 20, Marks = 500)

Course	Subject	Marks	Credits	Teaching hrs./week
Core Courses				
Core Course-11	PHE-MC11: Condensed Matter Physics-I	75	3	4 hrs.
Core Course-12	PHE-MC12: Electronics III - Microprocessors and Microcontrollers	75	3	4 hrs.
Core Course-13	PHE-MC13: Electronics IV- Electronics Instrumentation & Power Electronics	75	3	4 hrs.
Core Course-14	PHE-MC14: Physics Laboratory-III and project work	125	5	9 hrs.
Elective Courses - Choose any Two of the listed Discipline Specific Elective Courses*. Candidate may choose one of the Generic Elective Course** in place of one of Discipline Specific Elective Courses.				
Discipline Specific Elective Course-1		75	3	4 hrs.
Discipline Specific Elective Course-2		75	3	4 hrs.
Generic-Elective Courses**				
Generic-Elective Course-1		75	3	4 hrs.

Semester IV (Credits = 20, Marks = 500)

Course	Subject	Marks	Credits	Teaching hrs./week
Core Course - Choose any Two of the Nuclear Physics-II, Particle Physics-II and Condensed Matter Physics-II				
Core Course-15	PHE-MC15 - Electronics V - Advanced Microcontrollers and Microprocessors	100	4	4 hrs.
Core Course-16	PHE-MC16 - Electronics VI - Integrated and VLSI Circuit design	100	4	4 hrs.
Core Course-17	PHE-MC17 - Electronics VII - Digital Signal Processing	100	4	4hrs.
Elective Courses - Choose any two of the listed Discipline Specific Elective Courses*. Candidate may choose one of the Generic Elective Course** in place of one of the Discipline Specific Elective Courses.				

Discipline Specific Elective Course-3		100	4	4 hrs.
Discipline Specific Elective Course-4		100	4	4 hrs.
Generic-Elective Courses**				
Generic-Elective Course-2		100	3	4 hrs.

*** DISCIPLINE SPECIFIC ELECTIVE (DSE) COURSES (Semesters III and IV)**

Choose any two DSE courses in semester III and IV. A DSE Course will be offered only if a minimum of 10 students opt for the same and depending on the faculty available.

A. Choose any two of the following in each of semesters III and IV:

1. PHE-MDS1 Nuclear Physics I
2. PHE-MDS2 Particle Physics I
3. PHE-MDS3 Exp. Tech. in Nuclear & Particle Physics
4. PHE-MDS4 Exp. Tech. in Atomic, Molecular & Solid State Physics
5. PHE-MDS5 Space Science and Technology
6. PHE-MDS6 Astrophysics
7. PHE-MDS7 Fibre Optics and Non-linear Optics
8. PHE-MDS8 Informatics
9. PHE-MDS 9 Nonlinear Dynamics
10. PHE-MDS10 Particle Accelerator Physics
11. PHE-MDS11 Physics of Nano-materials
12. PHE-MDS12 Science of Renewable Energy Sources
13. PHE-MDS13 Advanced Statistical Mechanics
14. PHE-MDS14 Quantum Computations
15.

B. One of the following will be offered in each of semester IV. Allottment will be on merit of results of Semesters I and Ii:

1. PHE-MDS15 Physics Laboratory-IV
2. PHE-MDS15 (i) Project work (Electronics) Experimental
3. PHE-MDS15 (ii) Project work (Nuclear Physics) Experimental
4. PHE-MDS15 (iii) Project work (Particle Physics) Experimental
5. PHE-MDS15 (iv) Project work (Condensed Matter Physics) Experimental
6. PHE-MDS15 (v) Project work (Atomic and Molecular Physics) Experimental

THIRD SEMESTSR

PHE-MC11: Condensed Matter Physics-I

PHE-MC11 CONDENSED MATTER PHYSICS-I **Max. Marks: 15+60=75**

Note:

(i) The pattern of the question papers for the mid-term and end-semester examinations are given in the beginning of the syllabus.

(ii) The books indicated as text-book(s) are suggestive of the level of coverage. However, any other book may be followed.

I Elastic constants :

Binding in solids; Stress components, stiffness constant, elastic constants, elastic waves in crystals.

II Lattice Dynamics and Thermal Properties :

Rigorous treatment of lattice vibrations, normal modes; Density of states, thermodynamic properties of crystal, anharmonic effects, thermal expansion.

III Energy Band Theory :

Electrons in a periodic potential: Bloch theorem, Nearly free electron model; tight binding method; Semiconductor Crystals, Band theory of pure and doped semiconductors; elementary idea of semiconductor superlattices.

IV Transport Theory :

Electronic transport from classical kinetic theory; Introduction to Boltzmann transport equation; electrical and thermal conductivity of metals; thermoelectric effects; Hall effect and magnetoresistance.

V Dielectric Properties of Materials :

Polarization mechanisms, Dielectric function from oscillator strength, Clausius-Mosotti relation; piezo, pyro- and ferro-electricity.

VI Liquid Crystals :

Thermotropic liquid crystals, Lyotropic liquid crystals, long range order and order parameter, Various phases of liquid crystals, Effects of electric and magnetic field and applications, Physics of liquid crystal devices.

TUTORIALS : Relevant problems given in the books listed below.

Books :

1. Introduction to Solid State Physics : C. Kittel (Wiley, New York), 2005.

2. Quantum Theory of Solids : C. Kittel (Wiley, New York), 1987.

3. Principles of the Theory of Solids : J. Ziman (Cambridge University Press) 1972.

4. Solid State Physics : H. Ibach and H. Luth (Springer Berlin), 3rd ed. 2002.

5. Solid State Theory : Walter A. Harrison (Tata McGraw-Hill, New Delhi) 1970.

6. Liquid Crystals : S. Chandrasekhar (Cambridge University), 2nd ed. 1992.

7. The Liquid Crystal Phases : Physics & Technology : T.J. Sluckin, Contemporary Physics (Taylor & Francis), 2000.

PHE-MC12: Electronics III - Microprocessors and Microcontrollers

PHE-MC12: Electronics-III MICROPROCESSORS AND MICROCONTROLLERS

Max. Marks:15+60= 75

Note:

(i) The pattern of the question papers for the mid-term and end-semester examinations are given in the beginning of the syllabus.

(ii) The books indicated as text-book(s) are suggestive of the level of coverage. However, any other book may be followed.

Microprocessor : Buffer registers, Bus oraganised computers, SAP-I, Microprocessor (μP) 8085 Architecture, memory interfacing, interfacing I/O devices. Assembly language programming : Instruction classification, addressing modes, timing diagram, Data transfer, Logic and Branch operations- Programming examples.

Programming techniques for 8085 microprocessor, Counters and timer delays, Stack and subroutines, Code conversion, BCD, Arithmetic and 16-bit Data operations, Interrupts of 8085, Vectored and nonvectored, maskable and nonmaskable interrupts.

Interfacing data converters – A/D and D/A, Programmable interface devices – 8255A programmable interface, Interfacing keyboard/Display and Seven-segment display

Interfacing Programmable Peripheral Devices – interfacing keyboard and seven segment display, 8254 programmable interval timer, 8259A programmable interval timer, 8259 Programmable Interrupt Controller.

Serial communications, Software controlled Asynchronous Serial I/O, Programmable communications interface 8251, RS232

Microcontrollers - Overview of the 8051 family, Architecture of 8051, Timers, Intruupts and serial communication in 8051, 8051 programming in C, 8051 timer programming in C, Serial port programming, Interrupts programming.

Books :

1. Ramesh S. Gaonkar, Microprocessor Architecture, Programming and Applications with 8085, (Prentice Hall) 2002.
2. Badri Ram, Advanced Microprocessors and Interfacing, (Tata McGraw Hill), 2001.
3. Douglas V. Hall, Microprocessors and Interfacing programming and Hardware (Tata McGraw Hill) 2005.
4. The 8051 Microcontroller and embedded Systems by M. Ali Mazidi, J.G. Mazidi and R.D.M. Mckinley (Pearson Education) 2009.
5. The 8051 Microcontroller – I. Scott Mackenzie, R. Chung Wei Phan (Dorling Kindersley (India)), 4th ed. 2007.
6. Microcontrollers - A.J. Ayala, (Penram International), 2nd ed. 1996.
7. Microcontrollers : Arch., Programming, Interfacing & System design, Rajkamal, (Dorling Kindersley (India)), 2009.
8. Microcontroller (Theory & Applications), Ajay V Deshmukh (Tata McGraw Hill) 2012.
9. Embedded System Design, Rajeshwar Singh (Dhanpat Rai), 2nd Ed. 2009.

PHE-MC13: Electronics IV- Electronics Instrumentation & Power

PHE-MC13: ELECTRONICS INSTRUMENTATION & POWER ELECTRONICS

Max. Marks:15+60= 75

Note:

(i) The pattern of the question papers for the mid-term and end-semester examinations are given in the beginning of the syllabus.

(ii) The books indicated as text-book(s) are suggestive of the level of coverage. However, any other book may be followed.

I. Electronics Instrumentation

Electrical Transducers: Active Types - Thermoelectric, Piezoelectric, Magnetostrictive, Hall effect type, Electromechanical, Accelerometer, Photoelectric, Ionization, Electrochemical, Measurement of Power and RF Power, Transducers for biological applications. Measurements of electrical parameters and non-electrical parameters. Digital Sensors: Chemical sensors, Optochemical sensors, Electrochemical sensors, Biosensors, IR / PIR Sensors and motion detectors, Semiconductor sensors, Smart sensors, Charge coupled devices and its applications in imaging.

Feedback Transducer Systems - Inverse transducers, Temperature balance system, Self-balancing potentiometers and bridges, Heat-flow balance Systems, Beam balance systems, Servo-operated Manometer, Feedback Pneumatic Load Cell, Servo-operated Electromagnetic flow meter, Feedback accelerometer System, Integrating Servo, Other applications of feedback system.

Wave analyzers and Harmonic distortion: Frequency selective wave analyzer, Heterodyne Wave analyzer, Spectrum analyzer, Digital Fourier Analyzer.

II. Power electronics

Regulated Power Supplies – Regulated Power Supplies, Supply characteristics, Domestic and industrial Power backup systems, Diodes for high voltage power supplies, Shunt and series regulators, Monolithic linear regulators, Current boosters, DC-to-DC converters, Switching regulators

Semiconductor power devices - Basic characteristics & working of Power Diodes, Diac, SCR, Triac, Power Transistor, MOSFETs, IGBT, and GTO.

Devices of Thyristor family and their Switching characteristics, GTO, MOSFET, IGBT, Thyristor, triggering and commutation circuits, Thyristor protection circuits, SCR Crowbar circuit.

Principle of operation of choppers - Step up, Step down and reversible choppers.

High frequency electronic ballast, Switch Mode Power Supply: Fly back converter, forward/buck converter, Boost converter and buck-boost converter.

Uninterruptible Power Supply.

Phase controlled rectifiers for different loads with and without freewheeling diode.

Inverters – single phase series and parallel inverters, single phase and three phase inverters, Pulse width modulated inverters, Cycloconverters

DC and AC drives – Single-phase and three-phase converter drives, Chopper drives, Induction motor drives, Microprocessor controlled electrical drives

Books:

1. Transducers and Instrumentation by D.V.S. Murty, (Prentice-Hall of India Private Limited, New Delhi), 2004.
2. Modern Electronic Instrumentation and Measurement Techniques, A.D. Helfrick and William D. Cooper, (Prentice Hall of India, New Delhi), 1990.
3. Design of Medical Electronic Devices by Reinaldo Perez, (Academic Press), 2002.
4. Introduction to Instrumentation and Control, A.K. Ghosh, (Prentice Hall of India), 2000.
5. Measurement and Instrumentation Principles, Alan S Morris, (Prentice Hall of India), 2001.
6. Power Electronics by C.W. Lander, (McGraw Hill Book Company, Singapore) 1993.
7. Mohammed H. Rashid, Power Electronics-Circuits, Devices and Applications, (Prentice Hall of India, New Delhi) 2001.

PHE-MC14: Physics Laboratory-III and project work

PHE-MC14: Physics Laboratory III **Max. Marks: 25+100=125**

Note:

(i) Students are expected to perform at least 10 experiments in each semester. The experiments performed in first semester cannot be repeated in second Semester.

(ii) Each student will complete a project work and give seminar on one of the topics on Advances in Electronics during first year. Project work will consist of understanding, handling and repair of Audio-Video and communication Electronics Equipment.

(iii) The evaluation procedure for the Practical examination is given in the beginning of the syllabus.

List of Experiments :

1. To determine the g-factor of free electron using ESR.

2. To measure dielectric constant of barium titanate as function of temperature and frequency and hence study its phase transition.

3. To study structural and melting transition in KNo_3 using Differential Thermal Analyser.

4. To study Martensite to Austenite phase transition in Shape memory alloy Nitinol.

5. To study Metal-Insulator transition in a thin film of strontium doped lanthanum mangenite

6. To study thermoluminescence of F-centres in alkali halide crystals.

7. To study Raman scattering in CCl_4 .

8. To study Zeeman effect by using Na lamp.

9. Determination of velocity of light using modulated Laser method

10. Hands on experience on X-ray diffractometer for studying (i) Crytal structure (ii) Phase identification and (iii) size of nanoparticles.

11. 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.

12. To measure (i) dielectric constant of solid/liquid; (ii) Q of a cavity. Use of Klystron-based microwave generator.

13. To plot polar pattern and gain characteristics of Pyramidal horn antenna and parabolic dish for microwaves.

14. Scanning tunneling microscope – hardware and software familiarization, Atomic lattice image of graphite, Study of thin film and nanogrid .

15. Energy calibration of a gamma-ray spectrometer and determination of the energy resolution by using multi-channel analyzer.

16. To study time resolution of a gamma-gamma ray coincidence set-up.

17. To study anisotropy of gamma-ray cascade emission in ^{60}Ni (^{60}Co source) using a coincidence set-up.

18. Time calibration and determination of the time resolution of a coincidence set-up using a multi- channel analyzer.

19. To study calibration of a beta-ray spectrometer.

20. To study scattering of gamma rays from different elements.

21. To determine range of Alpha-particles in air at different pressure and energy loss in thin foils.

22. To determine strength of alpha particles using SSNTD.

23. *To measure* $p\beta$ of a particle using emulsion track.

24. To study p-p interaction and find the cross-section of a reaction using a bubble chamber.

25. To study n-p interaction and find the cross-section using a bubble chamber.

26. To study k-d interaction and find its multiplicity and moments using a bubble chamber.

27. To study a ((event using emulsion track.

28. To design (i) Low pass filter (ii) High pass filter (iii) All-pass filter (iv) Band pass filter (v) Band-reject filter using 741 OPAMP.

29. To study of Switched-mode power supply.

30. To study Phase Locked Loop (PLL) – (i) adjust the free running frequency (ii) determination of lock range and capture range (iii) determine the dc output from Frequency modulated wave.

31. Measurement of (i) low resistance (ii) Mutual inductance using Lock- In-Amplifier

32. Frequency modulation using Varactor and Reactance modulator and Frequency demodulation using Quadrature detector and Phased Locked Loop detector.

33. Dynamics of non-linear systems – (i) Feigenbaum Circuit and (ii) Chua Circuit.

34. Computer controlled experiments and measurements (Phoenix kit and Python language) – Digital and analog measurements based experiments.

35. Control of devices and data logger using parallel port of PC – programming using Turbo C.

36. Programming of parallel port of PC using C-language and control of devices connected.

37. 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.

38. (a) Selection of port for I & O and generation of different waveforms (b) control of stepper motor.

39. Microcontroller kit: hardware familiarization of (Controller and universal programmer and programming for four digit seven segment multiplexed up-conter upto 9999.

40. (a) EEPROM based 8 to 3 encoder using microcontroller (b) interfacing with ADC (temperature sensor) and DAC (variable voltage source).

41. Digital signal processing – TMS 320 C6713 Processor board, hardware familiarization, audio/speech applications using stereo CODEC device.

42. Microcontroller based Data Logger for PC.

43. Microcontroller AVR/ARM/PIC and interface with LCD, Temperature measurements,Traffic light, Stepper motor, Accelerometer, ADC and DAC modules, Colour, Proximity, Humidity and Pressure sensors. DTMF, RF and IR control modules.

44. Use of Digital storage oscilloscope for (a) plotting v-i characteristics; and (b) measuring speed of e.m. waves in coaxial cables.

Project Work : Develop a new experiment or perform open-ended thorough investigations using the available set-up. Weightage of the project work equal to few experiments to be decided by the teachers.

FOURTH SEMESTER

PHE-MC15 - Electronics V - Advanced Microcontrollers and Microprocessors

PHE-MC15: ADVANCED MICOCONTROLLERS & MICROPROCESSORS

Max. Marks: 20+80 = 100

Note:

(i) The pattern of the question papers for the mid-term and end-semester examinations are given in the beginning of the syllabus.

(ii) The books indicated as text-book(s) are suggestive of the level of coverage. However, any other book may be followed.

Unit I

Advanced Microcontrollers

Interfacing of 8051 with LCD, Keyboard, ADC, DAC and sensors, Interfacing to external memory, Interfacing with 8255 I/O chip, DS12887 RTC interfacing and programming.

Application of Microcontrollers in interfacing, Robotics, MCU based measuring instruments.

PIC and ARM microcontrollers, Architecture, Memory organization.

Unit II

Advanced Microprocessors

8086 Architecture- Hardware specifications, Pin-outs and pin functions, Internal data operations and Registers, Minimum and maximum mode, System Bus Timing, Linking and execution of Programs, Assembler Directives and operators.

Software & instruction set- Assembly language programming: addressing mode and instructions of 8086, MACRO programming, 8086 interrupts.

Analog interfacing & Digital interfacing, Programmable parallel ports, Memory interfacing and Decoding, DMA controller, basic I/O interface and interrupt handling.

8087 Math coprocessor.

32 Bit Processors - Basic features of 80386, Architecture, Special Registers, memory management using Descriptors and Selector tables, Accessing extended memory, virtual memory in protected mode.

Features of 80486 and Pentium processors.

Bus Interface : ISA, PCI and AGP slots, Serial, parallel and USB ports.

Books:

1. The 8051 Microcontroller and embedded Systems by M. Ali Mazidi, J.G. Mazidi and R.D.M. Mckinley (Pearson Education) 2009.
2. The 8051 Microcontroller – I. Scott Mackenzie, R. Chung Wei Phan (Dorling Kindersley (India)), 4th ed. 2007.
3. Microcontrollers - A.J. Ayala, (Penram International), 2nd ed. 1996.
4. Microcontrollers : Arch., Programming, Interfacing & System design, Rajkamal, (Dorling Kindersley (India)), 2009.
5. Microcomputer Systems: The 8086/8088 Family- Yu Cheng Liu and G.A. Gibson, (Prentice Hall of India), 1991.
6. The 8086/8088 Family Design, programming and interfacing- John Uffenbeck, (Prentice Hall of India), 1987.
7. Embedded C Programming & the Microchip PIC, Barnett Cox and O' Cull (Thomson Learning Asia), 2004.
8. The Intel Microprocessors, Barry B. Brey, Eighth ed. (Prentice Hall, India), 2009.
9. Advanced Microprocessor, U.S. Shah, Second ed. (Tech-Max Pub.) 2006.

PHE-MC16 - Electronics VI - Integrated and VLSI Circuit design

PHE-MC16: Electronics VI INTEGRATED AND VLSI CIRCUIT DESIGN

Max. Marks: 20+80=100

Note:

(i) The pattern of the question papers for the mid-term and end-semester examinations are given in the beginning of the syllabus.

(ii) The books indicated as text-book(s) are suggestive of the level of coverage. However, any other book may be followed.

I. Introduction to technologies- Semiconductor Substrate-Crystal defects, Electronic Grade Silicon, Czochralski Growth, Float Zone Growth, Characterization & evaluation of Crystals; Wafer Preparation- Silicon Shaping, Etching and Polishing, Chemical cleaning. Diffusion & ion implantation- Ficks diffusion Equation, Diffusion in SiO_2, Ion Implantation, Oxidation. Growth mechanism and Deal-Grove Model of oxidation, Linear and Parabolic Rate co-efficient, Structure of SiO_2, Oxidation techniques and system.

II. Chemical vapour deposition and layer growth- CVD for deposition of dielectric and polysilicon, Introduction to atmospheric CVD of dielectric, low pressure CVD of dielectric and semiconductor, Epitaxy-Vapour Phase Epitaxy, Defects in Epitaxial growth, Metal Organic Chemical Vapor Deposition, Molecular beam epitaxy.

III. Pattern transfer- Introduction to photo/optical lithography, Contact/ proximity printers, Projection printers, Mask generation, photoresists. Wet etching, Plasma etching, VLSI process integration- Junction and Oxide Isolation, LOCOS methods, Trench Isolation, SOI; Metallization, NMOS and CMOS IC Technology, Bipolar IC Technology. Packaging of VLSI devices

IV. MicroElectro-Mechanical Systems (MEMS), Working principles of microsensors and microactuation, scaling laws in geometry, Physical Microsensors, Optical MEMS (MOEMS), fluidic, RF and Bio-MEMS, e.g., DNA-chip, micro-arrays, Materials for MEMS, Microfabrication and Micromachining processes, Isotropic Etching and Anisotropic Etching, Bulk Micromachining, Deep Reactive Ion Etching (DRIE), high aspect ratio Si structures, LIGA process, Surface micromachining, pressure sensors, accelerometers, flow sensors, gas sensors, micromotors, microgears, lab-on-a-chip systems, Microactuators, Electromagnetic and Thermal microactuation, Mechanical design and examples.

V. Physics of nanomaterials, quantum transport phenomenon, Overview of quantum dots, resonant tunneling devices, Introduction to Nano electromechanical systems (NEMS), Introduction to Molecular electronic devices, self assembled monolayers (SAM), Diodes, Optoelectronic devices, switches, Nanowires.

Books :

1. VLSI Technology by Simon Sze, (Tata McGraw Hill), 2nd ed. 2003.

2. VLSI Design Techniques for Analog and Digital Circuits, Randall Geiger, (McGraw Hill) 2000.

3. An introduction to Microelectromechanical system Engineering, Nadim Maluf, (Artech House) 1998.

4. MEMS and MICROSYSTEMS – design and Manufacture, Tai-Ran Hsu (Tata McGraw Hill) 2002.

5. Fundamentals of Microfabrication, Marc Madou, (CRC Press) 1990.

6. MEMS and NEMS by Sergey Edward Lyshevski, (CRC Press) 2002.

Electronics VII - Digital Signal Processing

PHE-MC17: Electronics-VII DIGITAL SIGNAL PROCESSING

Max. Marks: 20+80 = 100

Note:

(i) The pattern of the question papers for the mid-term and end-semester examinations are given in the beginning of the syllabus.

(ii) The books indicated as text-book(s) are suggestive of the level of coverage. However, any other book may be followed.

I. Introduction to DSP Systems, Continuous and discrete-time signals, frequency ranges of various signals, Noise types.

Sampling of analog signals, Sampling theorem, Aliasing, Quantization, SQNR, noise.

Classification of Discrete-Time (DT) systems, Analysis of Discrete-Time Linear Time-Invariant (LTI) systems and their implementation, DT systems described by difference equations, Correlation sequences of DT signals and Input-output of LTI systems.

II. Z-Transform and its properties, Analysis of Discrete time LTI Systems in Z-domain.

Phase and Frequency response of LTI systems, Computation of response from a rational system function, Input-output correlation functions and spectra, correlation function and power spectra for random input signals, LTI systems as frequency-selective filters, system functions for LP, HP, BP, BR and AP filters, comb filters, digital resonators.

III. Frequency analysis of Discrete-Time signals, Fourier series for Discrete-time periodic signals and power density spectrum, Fourier transform of Discrete-time Aperiodic signals and energy density spectrum, frequency-domain classification of signals, properties of Fourier transform for discrete-time signals.

Frequency domain sampling and reconstruction of discrete-time signals, Discrete Fourier Transform (DFT) and its inverse, DFT as linear transformation, properties of DFT and applications in digital signal processing, Linear filtering of long data sequences, Overlap-save method, Overlap-add method.

Efficient computation of DFT– Divide-and Conquer approach, Radix-2 FFT algorithm, decimation-in-time algorithm, decimation-in-frequency algorithm.

IV. Implementation of DT system – structures of FIR and IIR systems

Finite impulse response (FIR) filters, Symmetric and Antisymmetric FIR filters, design of Linear-Phase FIR filters using windows.

Infinite impulse response (IIR) digital filter design by - Approximation of derivatives, Impulse invariance and Bilinear transformation.

V. Multirate Digital signal processing, Decimation and interpolation of sample rate, Sampling rate conversion by a rational factor I/D, Noble identities, cascaded integrator comb filters.

Concepts of Adaptive digital filters and applications.

VI. DSP arithmetic - Fixed-point and floating-point processors, main errors.

Architectures for signal processing, pipelining instructions, Replication, Extended parallelism–SIMD, VLIW and static superscalar processing, Circular Buffering, Barrel shifters, ADSP and TMS series of processor architectures, Selecting digital signal processors.

Books :

1. Digital Signal Processing: Principles, Algorithms, and Applications by J. G. Proakis and D. G. Manolakis (Pearson) 4th Ed. 2007.
2. Digital signal processing-A practical approach by Emmanuel C. Ifeachor and Barrie W. Jervis, (Pearson education, Asia) 2nd edition, 2001.
3. Digital Signal Processing – S. Salivahanan, A. Vallavaraj and C. Gnanapriya, (Tata McGraw Hill) 2010.
4. Digital Signal Processing – Sanjay Sharma, (S.K. Kataria and Sons, New Delhi), 2008.
5. Digital Signal Processing by Avtar Singh and S. Srinivasan, (Thomson Publications) 2004.

DISCIPLINE SPECIFIC ELECTIVE (DSE) COURSES (Semesters III and IV)

Nuclear Physics I

PHE-MDS1: NUCLEAR PHYSICS-I **Max. Marks: 15+60 = 75**

Note:

(i) The pattern of the question papers for the mid-term and end-semester examinations are given in the beginning of the syllabus.

(ii) The books indicated as text-book(s) are suggestive of the level of coverage. However, any other book may be followed.

I Static properties of nuclei : Nuclear radii and measurements, nuclear binding energy (review), nuclear moments and systematic, wave-mechanical properties of nuclei, hyperfine structure, effect of external magnetic field, Nuclear magnetic resonance.

II Radioactive decays : Review of barrier penetration of alpha decay & Geiger-Nuttal law. Beta decays, Fermi theory, Kurie plots and comparative half lives, Allowed and forbidden transitions, Experimental evidence for Parity-violation in beta decay, Electron capture probabilities, Double beta decay, Neutrino, detection of neutrinos, measurement of the neutrino helicity.

Multipolarity of gamma transitions, internal conversion process, transition rates, Production of nuclear orientation, angular distribution of gamma rays from oriented nuclei.

III Nuclear forces : Evidence for saturation of nuclear density and binding energies (review), types of nuclear potential, Ground and excited states of deuteron, dipole and quadrupole moment of deuteron, n-p scattering at low energies, partial wave analysis, scattering length, spin-dependence of n-p scattering, effective-range theory, coherent and incoherent scattering, central and tensor forces, p-p scattering, exchange forces & single and triplet potentials, meson theory of nuclear forces.

IV Neutron physics : Neutron production, slowing down power and moderating ratio, neutron detection.

V Nuclear reactions: Nuclear reactions and cross-sections, Resonance, Breit-Wigner dispersion formula for l=0 and higher values, compound nucleus, Coulomb excitation, nuclear kinematics and radioactive nuclear beams.

TUTORIALS : Relevant problems given in the books listed below:

Books :

1. Nuclear Physics : Irving Kaplan (Narosa), 2002.

2. Basic Ideas and Concepts in Nuclear Physics by K. Hyde (Institute of Physics) 2004.

3. Introduction to Nuclear Physics ; Herald Enge (Addison-Wesley) 1971.

4. Nuclei and Particles : E. Segre, (W.A. Benjamin Inc), 1965.

5. Theory of Nuclear Structure : R.R. Roy and B.P. Nigam (New Age, New Delhi) 2005.

6. Nuclear Physics: Experimental and Theoretical, H.S. Hans (New Academic Science) 2nd ed. 2011.

PHE-MDS2 Particle Physics I

PHE-MDS2: PARTICLE PHYSICS – I **Max. Marks: 15+60 = 75**

Note:

(i) The pattern of the question papers for the mid-term and end-semester examinations are given in the beginning of the syllabus.

(ii) The books indicated as text-book(s) are suggestive of the level of coverage. However, any other book may be followed.

I Introduction : Fermions and bosons, particles and antiparticles, quarks and leptons, interactions and fields in particle physics, classical and quantum pictures, Yukawa picture, types of interactions - electromagnetic, weak, strong and gravitational, units.

II Invariance Principles and Conservation Laws : Invariance in classical mechanics and in quantum mechanics, Parity, Pion parity, Charge conjugation, Positronium decay. Time reversal invariance, CPT theorem.

III Hadron-Hadron Interactions : Cross section and decay rates, Pion spin, Isospin, Two-nucleon system, Pion-nucleon system, Strangeness and Isospin, G-parity, Particle production at high energy.

IV Relativistic Kinematics and Phase Space : Introduction to relativistic kinematics, particle reactions, Lorentz invariant phase space, two-body and three-body phase space, recursion relation, effective mass, dalitz, K-3π-decay, τ-θ puzzle, Dalitz plots for dissimilar particles, Breit-Wigner resonance formula, Mandelstem variables.

V Static Quark Model of Hadrons : The Baryon decuplet, quark spin and color, baryon octet, quark-antiquark combination.

VI Electrodynamics and Chromo dynamics of Quarks: Hadron production in e^+e^- collisions, Elastic electron-proton scattering, Feynman rules for Chromo-dynamics, color factors, quark and antiquark, quark and quark, Asymptotic freedom.

VII Weak Interactions : Classification of weak interactions, Charged Leptonic Weak Interactions, Decay of the muon, Decay of the pion, Charged Weak Interactions of quarks, neutral weak interactions, helicity of neutrino, K-decay, CP violation in K-decay and its experimental determination.

VIII Cosmic rays, origin and composition, energy spectrum, acceleration and propagation of UHE (>10^{14} eV) particles, Cosmic ray shower, Measurements of UHE cosmic rays on earth (GRAPES experiment).

Books :

1. Introduction to High Energy Physics : D.H. Perkins (Cambridge University Press), 4th ed. 2000.

2. Elementary Particles : I.S. Hughes (Cambridge University Press), 3rd ed. 1991.

3. Introduction to Quarks and Partons : F.E. Close (Academic Press, London), 1979.

4. Introduction to Particle Physics : M.P. Khanna (Prentice Hall of India, New Delhi), 2004.

PHE-MDS3 Exp. Tech. in Nuclear & Particle Physics

PHE-MDS3: EXPERIMENTAL TECHNIQUES IN NUCLEAR PHYSICS AND PARTICLE PHYSICS

Max. Marks: 20+80 = 100

Note:

(i) The pattern of the question papers for the mid-term and end-semester examinations are given in the beginning of the syllabus.

(ii) The books indicated as text-book(s) are suggestive of the level of coverage. However, any other book may be followed.

I **Detection of radiations:** Interaction of gamma-rays, electrons, heavy charged particles, neutrons, neutrinos and other particles with matter.

General properties of Radiation detectors, energy resolution, detection efficiency and dead time. Statistics and treatment of experimental data.

Gas-filled detectors, Proportional counters, space charge effects, energy resolution, time characteristics of signal pulse, position-sensitive proportional counters, Multiwire proportional chambers, Drift chamber, Time projection chamber.

Organic and inorganic scintillators and their characteristics, light collection and coupling to photomultiplier tubes and photodiodes, description of electron and gamma ray spectrum from detector, phoswich detectors, Cherenkov detector.

Semiconductor detectors, Ge and Si(Li) detectors, Charge production and collection processes, detector structures and fabrication aspects, semiconductor detectors in X- and gamma-ray spectroscopy, Pulse height spectrum, Compton suppressed Ge detectors, Semiconductor detectors for charged particle spectroscopy and particle identification, Silicon strip detectors, Radiation damage.

Electromagnetic and Hadron calorimeters.

Motion of charged particles in magnetic field, Magnetic dipole and quadrupole lenses, beta ray spectrometer.

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

General Background and detector shielding.

II **Electronics associated with detectors :** Electronics for pulse signal processing, CR-$(RC)_n$ and delay-line pulse shaping, pole-zero cancellation, baseline shift and restoration, preamplifiers (voltage and charge-sensitive configurations), overload recovery and pileup, Linear amplifiers, single-channel analyser, anolog-to-digital converters, multichannel analyzer.

Basic considerations in time measurements, Walk and jitter, Time pickoff methods, time-to-amplitude converters, Systems for fast timing, fast-slow coincidence, and particle identification, NIM and CAMAC instrumentation standards and data acquisition system.

III **Experimental methods :** 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), production of radioactive ion beams.

Detector systems for high energy experiments : Collider physics (brief account),

Particle Accelerators (brief account), Secondary beams, Beam transport, Modern

Hybrid experiments - CMS and ALICE.

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

Books :

1. Introduction to Experimental Particle Physics by Richard Fernow (Cambridge University Press), 2001.

2. Radiation detection and measurement by Glenn F. Knoll (Wiley), 2010.

3. Techniques in Nuclear and particle Experiments by W.R. Leo (Springer), 1994.

4. Detectors for particle radiation by Konrad Kleinknecht (Cambridge University Press), 1999.

PHE-MDS4 Exp. Tech. in Atomic, Molecular & Solid State Physics

PHE-MDS4 Exp. Tech. in Atomic, Molecular & Solid State Physics

Max. Marks: 15+60 = 75

Note:

(i) The pattern of the question papers for the mid-term and end-semester examinations are given in the beginning of the syllabus.

(ii) The books indicated as text-book(s) are suggestive of the level of coverage. However, any other book may be followed.

Unit-I

I. Revisit to Atomic and Molecular Physics:

Atomic Physics : 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 and vacancy decay mechanisms, Selection rules, X-ray spectra.

Lasers: Temporal and spatial coherence, Spontaneous and stimulated emission, line broadening mechanisms, rate equation, He-Ne laser, Nitrogen laser, CO_2 laser, Ruby laser, Holography.

Molecular Physics : Molecular spectra, symmetric structures, Frank-Condon principle. Born-Oppenheimer approximation. Electronic, rotational, vibrational and Raman spectra of diatomic molecules, selection rules.

II. Analytical techniques : (Brief account) Atomic Absorption and emission Spectrometers, UV-Vis Spectrometer, FTIR Spectrometer, Raman Spectrometer.

Electron spin resonance, Nuclear magnetic resonance.

TEM, AFM, STM, X-ray fluorescence, XRD.

III. Vacuum Techniques : Production and Measurements of vacuum**.**

Unit - II

IV. Detection of radiations: Interaction of gamma-rays, electrons, heavy charged particles, neutrons, neutrinos and other particles with matter.

Radiation detectors - energy resolution, detection efficiency and dead time. Statistics and treatment of experimental data.

Gas-filled detectors, Proportional counters, space charge effects, position-sensitive proportional counters.

Organic and inorganic scintillators and their characteristics, light collection and coupling to photomultiplier tubes and photodiodes, description of electron and gamma ray spectra from scintillation detector, Cherenkov detector.

Semiconductor detectors in X- and gamma-ray spectroscopy, Charge production and collection processes, Pulse height spectrum, Compton suppressed Ge detectors, Semiconductor detectors for charged particle spectroscopy. Detection of fast and slow neutrons - nuclear reactions for neutron detection. General Background and detector shielding. Beta ray spectrometer.

V. Electronics associated with detectors : Pulse height analysis - Electronics for pulse signal processing, Pulse shaping, pole-zero cancellation, preamplifiers (voltage and charge-sensitive configurations), Linear amplifiers, Single-channel analyser, multichannel analyzer.

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

VI. Experimental methods for nuclear and high energy experiments (Brief account) : Large gamma and charge particle detector arrays, multiplicity filters, electron spectrometer, heavy-ion reaction analysers, nuclear lifetime measurements (DSAM and RDM techniques). Mossbauer Spectroscopy.

Collider physics and Particle Accelerators, Secondary beams, Modern Hybrid experiments- CMS and ALICE.

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

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. Vacuum Technology: A. Roth (North Holland) (1990).

7. Introduction to Experimental Particle Physics by Richard Fernow (Cambridge University Press), 2001.

8. Radiation detection and measurement by Glenn F. Knoll (Wiley), 2010.

9. Techniques in Nuclear and particle Experiments by W.R. Leo (Springer), 1994.

10. Detectors for particle radiation by Konrad Kleinknecht (Cambridge University Press), 1999.

PHE-MDS5 Space Science and Technology

PHE-MDS5 SPACE SCIENCES AND TECHNOLOGY

Max. Marks 20+80=100

Note:

(i) The pattern of the question papers for the mid-term and end-semester examinations are given in the beginning of the syllabus.

(ii) The books indicated as text-book(s) are suggestive of the level of coverage. However, any other book may be followed

I Astronomy & Astrophysics: Stellar properties and associated astronomy; Interstellar medium; Galaxy structure and dynamics; Structure of star; Star formation and evolution; Red-giant stage, Supernovae, Black hole; Nucleosynthesis; Origin and the evolution of the Universe; Big-bang cosmology.

II Planetary Science: An introduction to the planets, satellites, asteroids, etc. and the associated planetary processes; Origin and the early evolution of the solar system; Formation & evolution of planets and satellites.

III Atmospheric Science: Physical and chemical characteristics of the Earth's atmosphere; Major regions of the atmosphere; Comparison with the atmosphere of other planets and satellites e.g., Venus, Mars, Titan; Evolution of planetary atmosphere; Sun-Earth interaction; Radiation balance; Concepts of climatic studies & global warming.

IV Space technology: Overview of the planetary missions by various space agencies e.g., NASA, ESA, ISRO, etc.; Science and technology related with the designing, launch, landing and orbit insertion of planetary spacecrafts/mission and satellites; Designing of planetary spacecrafts and missions; Elements of hyper-spectral imaging, SAR (Synthetic Aperture Radar), onboard optical, IR, UV, X-ray, γ-ray spectrometers and particle detectors.

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

Books:

1. Physics of stellar evolution and cosmology: H.S. Goldberg and M.D. Scadron (Gordon and Breach), 1986.
2. Theoretical Astrophysics (Vol. I, II, III): T. Padmanabhan (Cambridge University Press), 2005.
3. Moons and Planets: W. K. Hartmann (Wadsworth Publishing Company), 1999.
4. Basics of Atmospheric science: A. Chandrasekhar (PHI Learning Private Limited), 2011.
5. Space Technology: J. A. Angelo (Greenwood Press), 2003.

PHE-MDS6 Astrophysics

PHE-MDS6 ASTROPHYSICS

Max. Marks: 20+80=100

Note:

(i) The pattern of the question papers for the mid-term and end-semester examinations are given in the beginning of the syllabus.

(ii) The books indicated as text-book(s) are suggestive of the level of coverage. However, any other book may be followed.

I Introduction: Basic concepts of celestial sphere, Co-ordinate systems; Alt-azimuth, Equatorial, Right Ascension, Ecliptic, Basic stellar properties; Luminosity, apparent and absolute magnitude, photo visual and photographic magnitude system, estimation of distance using parallax method and Cepheid variables, stellar masses in binary system. Spectral classification of stars, Origin of emission and absorption spectra, Doppler effect and its applications, Mass-Luminosity relation;

free electron scattering and bound-free scattering, HR diagram. Basic concepts of astronomical observations in γ-rays, X-rays, UV,visible, infra-red, radio waves.

II Interstellar medium and molecular clouds: Structure of our galaxy, Globular clusters, velocity distribution of stars, origin of 21-cm radiation and interstellar gas, fine structure of Carbon, Origin of spiral arms and its basic features, Interstellar dust and theory of extinction of stellar light, molecules and molecular clouds, the galactic magnetic field, the active star forming molecular clouds.

III Stellar evolution and nucleosynthesis: Pre-main sequence collapse, origin of the solar system, Jean's criteria, Shedding excess of angular momentum and magnetic field, T Tauri phase, Quasi-hydrostatic equilibrium, Virial theorem, Radiative and convective heat transfer, the sun on the main sequence, rates of nuclear energy generation, the standard solar model, evolution of low, intermediate and high mass stars on HR diagram, late stage evolution of stars, red giant phase, white dwarf, supernova (type Ia, Ib/c, II), neutron star, black hole, stellar nucleosynthesis, hydrostatic and explosive nucleosynthesis, sprocess, r-process, the galactic chemical evolution.

IV Cosmology: Simple extragalactic observations, Olber's paradox, Hubble's constant and its implications, the steady state universe, Evolution of the Big Bang, hadron era, lepton era, primordial nucleosynthesis, the radiation era, the matter era, time evolution of the future universe.

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

Books:

1. Physics of stellar evolution and cosmology: H.S. Goldberg and M.D. Scadron (Gordon and Breach), 1986.

2. Astronomy: Principles and Practice : A.E. Roy and D. Clarke (Adam Hilger), 2003.

3. Theoretical Astrophysics (Vol. I, II, III) : T. Padmanabhan (Cambridge University Press), 2005.

PHE-MDS7 Fibre Optics and Non-linear Optics

PHE-MDS7: FIBRE OPTICS AND NON-LINEAR OPTICS

Max. Marks: 20+80 = 100

Note:

(i) The pattern of the question papers for the mid-term and end-semester examinations are given in the beginning of the syllabus.

(ii) The books indicated as text-book(s) are suggestive of the level of coverage. However, any other book may be followed.

I. Optical fibre and its properties: 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.

II. Fiber fabrication and cable design: Fibre fabrication, mass production of fiber, comparison of the processes, fiber drawing process, coatings, cable design requirements, typical cable design, testing.

III. 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.

IV. 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 electrooptic modulation, electro-optic amplitude modulation, electro-optic phase modulation, high frequency wave guide, electro-optic modulator, strain optic tensor, calculation of LM for a logitudinal acoustic wave in isotropic medium, calculation of LM for a shear wave in lithium niobate, Raman-Nath diffraction, Raman-Nath acousto-optic modulator.

V. Non-linear optics/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), 1996.

3. Optical Electronics : Gathak & Thyagarajan (Cambridge Univ. Press), 1989.

4. The Elements of Non-linear Optics: P.N. Butcher & D. Cotter (Cambridge University Press), 1991.

PHE-MDS8 Informatics

PHE-MDS8 INFORMATICS

Max. Marks: 20+80=100

Note:

(i) The pattern of the question papers for the mid-term and end-semester examinations are given in the beginning of the syllabus.

(ii) The books indicated as text-book(s) are suggestive of the level of coverage. However, any other book may be followed.

I Introduction : Computer hardware, software, programming languages, Fortran 77, classification of data, variables, dimension and data statement, input/output, format, branching, IF statements, DO statements, subprogrammes, operations with files.

II Operating Systems : Introduction to Unix/Linux and shell scripting, graphics and plotting, tools: internet, e-mail, etc. Conceptual framework of computer languages.

III Introduction to C++ : Basics of C++, Data types and operators, statements and control flow, functions and programme structure, classes in C++, strings, the preprocessor, pointers, C++ memory allocation, Input/output, subprogramme, recursion, file access.

IV Object Oriented Programming : Classes, objects, inheritence and encapsulation, interface and implementation, reuse and extension of classes, inheritence and polymorphism; analysis and design, notations for object – oriented analysis and design. Some applications using object oriented programming languages.

TUTORIALS : Solving problems pertaining to the topics covered in the course, using computers.

Books :

1. Fortran Programming : V. Rajaraman (Prentice-Hall of India, New Delhi), 2004.

2. Teach Yourself C++ : A. Stevens (BPB Pub., New Delhi), 2003.

3. Let us C++ : Y.P. Kanetkar (BPB Pub., New Delhi), 2008.

4. Object Oriented Systems Development using Unified Modeling Language : A Bahrami (McGraw-Hill, New York), 1999.

PHE-MDS9 NONLINEAR DYNAMICS

Max. Marks: 20+80=100

Note:

(i) The pattern of the question papers for the mid-term and end-semester examinations are given in the beginning of the syllabus.

(ii) The books indicated as text-book(s) are suggestive of the level of coverage. However, any other book may be followed.

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.

II Dynamics in State Space: State space, autonomous and nonautonomous 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, U-sequence.

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

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

V 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), 2001.

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.

PHE-MDS10 Particle Accelerator Physics

PHE-MDS10 PARTICLE ACCELERATOR PHYSICS

Max. Marks: 20+80=100

Note:

(i) The pattern of the question papers for the mid-term and end-semester examinations are given in the beginning of the syllabus.

(ii) The books indicated as text-book(s) are suggestive of the level of coverage. However, any other book may be followed.

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.

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.

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.

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

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

VI Applications : Use of accelerators for AMS and Ion-beam Analysis Techniques.

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).

PHE-MDS11 Physics of Nano-materials

PHE-MDS11 PHYSICS OF NANOMATERIALS

Max. Marks: 20+80=100

Note:

(i) The pattern of the question papers for the mid-term and end-semester examinations are given in the beginning of the syllabus.

(ii) The books indicated as text-book(s) are suggestive of the level of coverage. However, any other book may be followed.

I Introductory Aspects : Free electron theory and its features, Idea of band structure—metals, insulators and semiconductors. Density of state in one, two and three dimensional bands and its variation with energy, Effect of crystal size on density of states and band gap. Examples of nanomaterials.

II Preparation of Nanomaterials : Bottom up: Cluster beam evaporation, ion beam deposition, chemical bath deposition with capping techniques and Top down: Ball Milling.

III General Characterization Techniques : Determination of particle size, study of texture and microstructure, Increase in x-ray diffraction peaks of nanoparticles, shift in photo luminescence peaks, variation in Raman spectra of nanomaterials, photoemission microscopy, scanning force microscopy.

IV Quantum Dots : Electron confinement in infinitely deep square well, confinement in one and two-dimensional wells, idea of quantum well structure, Examples of quantum dots, spectroscopy of quantum dots.

V Other Nanomaterials : Properties and applications of carbon nanotubes and nanofibres, Nanosized metal particles, Nanostructured polymers, Nanostructured films and Nano structured semiconductors.

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

Books

1. Nanotechnology - Molecularly Designed Materials : G.M. Chow & K.E. Gonsalves (American Chemical Society), 1996.

2. Nanotechnology Molecular Speculations on Global Abundance : B.C. Crandall (MIT Press), 1996.

3. Quantum Dot Heterostructures: D. Bimerg, M. Grundmann and N.N. Ledentsov (Wiley), 1998.

4. Nanoparticles and Nanostructured Films–Preparation, Characterization and Application : J.H. Fendler (Wiley), 1998.

5. Nanofabrication and Bio-system: H.C. Hoch, H.G. Craighead and L. Jelinski (Cambridge Univ. Press), 1996.

6. Physics of Semiconductor Nanostructures: K.P. Jain (Narosa), 1997.

7. Physics of Low-Dimension Semiconductors: J.H. Davies (Cambridge Univ. Press) 1998.

8. Advances in Solid State Physics (Vo.41) : B. Kramer (Ed.) (Springer), 2001.

PHE-MDS12 Science of Renewable Energy Sources

PHE- MDS12 SCIENCE OF RENEWABLE ENERGY SOURCES

Max. Marks: 20+80 = 100

Note:

(i) The pattern of the question papers for the mid-term and end-semester examinations are given in the beginning of the syllabus.

(ii) The books indicated as text-book(s) are suggestive of the level of coverage. However, any other book may be followed.

I Introduction : Production and reserves of energy sources in the world and in India, need for alternatives, renewable energy sources.

II Solar Energy : Thermal applications, solar radiation outside the earth's atmosphere and at the earth's surface, fundamentals of photovoltaic energy conversion. Direct and indirect transition semi-conductors, interrelationship between absorption coefficients and band gap recombination of carriers.

Types of solar cells, p-n junction solar cell, Transport equation, current density, open circuit voltage and short circuit current, description and principle of working of single crystal, polycrystalline and amorphous silicon solar cells, conversion efficiency. Elementary ideas of Tandem solar cells, solid-liquid junction solar cells and semiconductor-electrolyte junction solar cells. Principles of photoelectrochemical solar cells. Applications.

III Hydrogen Energy : Environmental considerations, solar hydrogen through photo electrolysis and photocatalytic process, physics of material characteristics for production of solar hydrogen. Storage processes, solid state hydrogen storage materials, structural and electronic properties of storage materials, new storage modes, safety factors, use of hydrogen as fuel; use in vehicles and electric generation, fuel cells, hydride batteries.

IV Other sources : Nature of wind, classification and descriptions of wind machines, power coefficient, energy in the wind, wave energy, ocean thermal energy conversion (OTEC), system designs for OTEC.

TUTORIALS : Relevant problems on the topics covered in the course.

Books:

1. Solar Energy : S.P. Sukhatme (Tata McGraw-Hill, New Delhi), 2008.

2. Solar Cell Devices : Fonash (Academic Press, New York), 2010.

3. Fundamentals of Solar Cells, Photovoltaic Solar Energy : Fahrenbruch and Bube (Springer, Berlin), 1983.

4. Photoelectrochemical Solar Cells : Chandra (New Age, New Delhi).

PHE-MDS13 Advanced Statistical Mechanics

PHE-MDS13 ADVANCED STATISTICAL MECHANICS

Max. Marks: 20+80=100

Note:

(i) The pattern of the question papers for the mid-term and end-semester examinations are given in the beginning of the syllabus.

(ii) The books indicated as text-book(s) are suggestive of the level of coverage. However, any other book may be followed.

I Interacting Systems : Deviation of a real gas, Cluster expansion for a classical gas, Virial expansion of equation of state, Evaluation of virial coefficients, General remarks on cluster expansion; quantum mechanical ensemble theory, the density matrix, density matrix for a linear harmonic oscillator; cluster expansion for a quantum mechanical system. Bose condensation.

II Phase Transitions and Critical Phenomena : Phase transitions – General remarks on the problems of condensation, Dynamical model for phase transition—Ising and Heisenberg models, the lattice gas and binary alloy, Ising model in the Zeroth approximation, Matrix method for onedimensional Ising model. The critical indices, Law of Corresponding States, thermodynamic inequalities, Landau's phenomenological theory; Scaling hypothesis.

III Brownian Motion : Spatial correlation in a fluid, Einstein-Smoluchowski theory, Langevin theory, The Fokker-Planck equation.

IV The Time Correlation Function Formalism : Concept of time correlation function, derivation of basic formulas of linear response theory, Time-Correlation function expressions for thermal transport coefficients and their applications. The Wiener - Khintchine theorem, the fluctuation dissipation theorem. The Onsagar relations.

TUTORIALS : Relevant problems given at the end of each chapter in books 1 and 2.

Books:

1. Statistical Mechanics : R.K. Pathria (Butterworth-Heinemann, Oxford), 3rd ed, 2011.

2. Statistical Mechanics : D.A. Mc Quarrie (Harper and Row), 2000.

3. Introduction to Modem Statistical Mechanics : D. Chandler (Oxford Univ. Press), 1987.

4. Statistical Mechanics : K. Huang (Wiley Eastern, Delhi), 1987.

5. Statistical Mechanics and Properties of Matter : ESR Gopal (Macmillan India, Delhi), 1988.

PHY-MDS14 Quantum Computations

Max. Marks: 20+80=100

Review of Mathematical Physics

1. Number systems: Decimal and binary numbers
2. Basic linear algebra: vector space, superposition, linear dependence, basis states, tensor sum, inner products, tensor products
3. Operator algebra: Basic operators, brackets and algebra, functions, identities, eigenvalue equations, representations
4. Basic group theory and algebra: SL (2, C), SO(n), SU(n), Lie algebra, permutation group
5. Fourier transforms: Discrete and fast Fourier transforms

Review of Quantum mechanics

1. Dirac bra-ket notation: State and operator representation, base kets and matrix representation
2. Superposition principle: superposition of states
3. Measurement collapse of wave-function
4. Unitary operations: Hermiticity, Pauli operators, infinitesimal operators
5. Stern-Gerlach experiment: collapse of states, weight redistribution
6. Density matrix and pure vs mixed ensembles: Properties of density matrix

Classical Computation

7. How many digits?
8. Logic gates: AND, OR, N OT, NOR, XOR, NAND, FAN
9. Classical circuits: flip-flop, half and full adders, counters
10. Encoders and decoders:

Quantum Computation

11. Quantum bits: Multiple qubits
12. Physics of a single qubit: Mathematical and geometrical representation.
13. Hadamard and other quantum gates.
14. EPR paradox
15. Quantum entanglement
16. Bell's Inequalities
17. Experimental test of Bell's inequalities: Aspect experiment.
18. Quantum circuits: Single qubit operations, universal quantum gates, measurement.
19. Quantum algorithms: DJ Algorithm, Grover's algorithm and Shor's algorithm.
20. Quantum noise and quantum operations: Environment and quantum operations. Examples of quantum noise and quantum operations.

Physical Implementation of Quantum Computers

21. Divincenzo's criteria for constructing quantum computers.
22. Superconducting qubits: Qubits and gates of superconducting quantum systems
23. NMR quantum computing: Basic unit of information and gates.
24. Quantum optics: Photons as qubits, optical elements used as gates.
25. Ion traps: Qubits and basic gate implementation in an ion trap.

Reference:

1. George B. Arfken and Hans J. Weber, Mathematical Methods for Physicists
2. J. J. Sakurai: Modern Quantum Mechanics,
3. DJ Griffiths, Introduction to Quantum Mechanics
4. Michael A. Nielsen and Isaac L. Chuang, Quantum Computation and Quantum Information
5. Dancing with QUBITS: Robert S. Sutor

B. One of the following will be offered in each of semester IV. Allottment will be on merit of results of Semesters I and II

III. PHE-MDS15 Major Project Work
IV. PHE-MDS15 (i) Project work (Electronics) Experimental
V. PHE-MDS15 (ii) Project work (Nuclear Physics) Experimental
VI. PHE-MDS15 (iii) Project work (Particle Physics) Experimental
VII. PHE-MDS15 (iv) Project work (Condensed Matter Physics) Experimental
VIII. PHE-MDS15 (v) Project work (Atomic and Molecular Physics) Experimental

PHS MDS 15 – Electronics VIII MAJOR PROJECT WORK

Max. Marks: 100

The aim of project work in M.Sc (H.S.) 4th semester is to expose the students to **Instrumentation, Power Electronics, Microcontroller and DSP, Digital communication.** It may include development of pulse processing **electronic modules, power supplies,** software-controlled equipment in a research laboratory, or fabrication of a device. Project work based on participation in some ongoing research activity or analysis of data or review of some research papers is excluded. A student will work under the guidance of a faculty member from the department before the end of the 3rd semester. **Scientists and Engineers from other departments of the university and Institutes in and around Chandigarh can act as co-supervisors.** A report of nearly 50 pages about the work done in the project (typed on both the sides of the paper and properly bound) will be submitted by a date to be announced by the PGAPMEC. Assessment of the work done under the project will be carried out by a committee on the basis of grasp of the problem assigned, effort put in the execution of the project, degree of interest shown in learning the methodology, report prepared, and viva-voce/seminar, etc as per guidelines prepared by the PGAPMEC

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