M.Sc. in Physics

Under the Framework of Honours School System

Choice Based Credit System (CBCS)

Academic Session 2021-22

PANJAB UNIVERSITY, CHANDIGARH
OUTLINES OF TESTS, SYLLABI AND COURSES OF READING FOR CHOICE BASED CREDIT SYSTEM (CBCS) M.Sc. IN PHYSICS UNDER THE FRAMEWORK OF HONOURS SCHOOL SYSTEM EXAMINATION,
STARTING FROM ACADEMIC SESSION 2021-2022

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 programme are manifold and start with understanding diverse phenomena observed in nature through the fundamental concepts of Physics using logical and mathematical reasoning. 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, Statistical Mechanics and Thermodynamics, Electromagnetic Theory, Solid State Physics, Electronics, Nuclear Physics, Particle Physics and Atomic and Molecular Physics. The syllabus will provide comprehensive knowledge, and improve theoretical and practical skills of Physics subject. 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. 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 enprenuership 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 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 (Compulsary)				
Core Course-1	PHY-MC1: Mathematical Physics-I	75	3	4 hrs
Core Course-2	PHY-MC2: Classical Mechanics	75	3	4 hrs
Core Course-3	PHY-MC3: Quantum Mechanics	75	3	4 hrs
Core Course-4	PHY-MC4: Electronics-I	75	3	4 hrs
Core Course-5	PHY-MC5 : Physics Laboratory PHY-MC5A: Practical Laboratory-I PHY-MC5B: Computer Laboratory-I	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 (Compulsary)				
Core Course-6	PHY-MC6: Mathematical Physics	75	3	4 hrs
Core Course-7	PHY-MC7: Statistical Mechanics	75	3	4 hrs
Core Course-8	PHY-MC8: Relativistic Quantum Mechanics and Quantum Field Theory	75	3	4 hrs
Core Course-9	PHY-MC9: Classical Electrodynamics	75	3	4 hrs
Core Course-10	PHY-MC10 : Physics Laboratory PHY-MC10A: Practical Laboratory-II PHY-MC10B: Computer Laboratory-II	200 150 50	8 6 2	 9 hrs 4 hrs

---

M.Sc. (Hons. School) Physics 1st Year

FIRST SEMESTER

PHY- 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.

PHY- 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.

PHY – 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.

PHY – 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) 10^{th} ed. 2009.
11. OPAMPS and Linear Integrated circuits : Ramakant A Gayakwad (Prentice Hall), 1992.

PHY – MC5 PHYSICS LABORATORY I

PHY – 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 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* 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/Scientific Equipment Manufacturing Unit/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.

PHY – 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 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 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 1st Year

SECOND SEMESTER

PHY – MC6 MATHEMATICAL PHYSICS-II

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

Max. Marks: 15+60= 75

Objective: The aim and objective of the course on **Mathematical Physics-II** is to equip the M.Sc. 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: The pattern of the question papers for the mid-term and end-semester examinations are given in the beginning of the syllabus.

I Group Theory : What is a group ? Multiplication table, conjugate elements and classes, subgroups, Isomorphism and Homomorphism, Definition of representation and its properties, Reducible and irreducible representations, Schur's lemmas (only statements), characters of a representation. Example of C4v, Topological groups and Lie groups, three dimensional rotation group, special unitary groups SU(2) and SU(3).

II Fourier Series and Integral Transforms : Fourier series, Dirichlet conditions. General properties. Convolution and correlation, Advantages and applications, Gibbs phenomenon. Fourier transforms, Development of the Fourier integral, Inversion theorem, Fourier transforms of derivatives; Momentum representation.

Laplace transforms, Laplace transforms of derivatives, Properties of Laplace transform, Inverse Laplace transformation. Applications.

III Integral Equations : Definitions and classifications, integral transforms and generating functions. Neumann series, Separable Kernels, Hilbert-Schmidt theory. Green's functions in one dimension.

IV Elements of Computational techniques: Numerical differentiation, Euler method, Runge-Kutta second and fourth order methods, Finite difference methods, Numerical integration, Trapezoidal rule, Simpson's rule, Interpolation and Extrapolation, Least square fit (for linear and parabola behaviour)

V Elementary Statistics: Introduction to probability theory, random variables, Binomial, Poisson and Normal distributions, Central limit theorem.

TUTORIALS : Relevant problems given in the books listed below .

Suggested Reading:

1. Group Theory for Physicists : A.W. Joshi (Wiley Eastern, New Delhi) 2011.
2. Mathematical Methods for Physicists : G. Arfken and H.J. Weber, (Academic Press, San Diego) 7th edition, 2012.
3. Matrices and Tensors in Physics : A.W. Joshi (Wiley Eastern, New Delhi) 2005.
4. Numerical Mathematical Analysis, J.B. Scarborough (Oxford Book Co., Kolkata) 4th edition.

Additional suggested Reading:

5. A First Course in Computational Physics: P.L. Devries (Wiley, New York) 1994.
6. Mathematical Physics : P.K. Chatopadhyay (Wiley Eastern, New Delhi) 2011.
7. Introduction to Mathematical Physics : C. Harper (Prentice Hall of India, New Delhi) 2006.

PHY – 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.

PHY-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.

PHY - 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.

PHY – MC10 PHYSICS LABORATORY II

PHY – 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* 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.) $1^{st}/2^{nd}$ 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.

PHY – 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.) 2^{nd} 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 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.