FACULTY OF SCIENCE

SYLLABI

FOR

M.Sc. (HONOUR SCHOOL) PHYSICS

1st TO 4th SEMESTER EXAMINATIONS

2013 – 2014 session onwards

Syllabi applicable for admissions in 2013

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OUTLINES OF TESTS, SYLLABI AND COURSES OF READING FOR 
M. Sc. (HONS. SCHOOL) IN PHYSICS 
FIRST AND SECOND YEAR (SEMESTER SYSTEM) EXAMINATION

<table>
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<tr>
<th>M.Sc. (H.S.) First Year</th>
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<tr>
<td>PHYS 411H Mathematical Physics I</td>
<td>4</td>
<td>75</td>
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<td>PHYS 412H Classical Mechanics</td>
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<td>PHYS 413H Quantum Mechanics</td>
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<td>PHYS 414H Electronics I</td>
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<tr>
<td>PHYS 415H Physics Laboratory I</td>
<td>9</td>
<td>150</td>
<td>6</td>
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<td>PHYS 416H Computational Physics I</td>
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<td>PHYS 424H Classical Electrodynamics</td>
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<td>PHYS 425H Physics Laboratory II</td>
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<th>M.Sc(H.S.) Second Year*</th>
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<tr>
<td><strong>Third Semester</strong></td>
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<tr>
<td>PHYS 511H Classical Electrodynamics and General Theory of Relativity</td>
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<tr>
<td>PHYS 512H Condensed Matter Physics I</td>
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<td>PHYS 513H Nuclear Physics I</td>
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<td>PHYS 514H Particle Physics I</td>
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<td>PHYS 516H Physics Laboratory III</td>
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<td>PHYS 522H Nuclear Physics II</td>
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<td>PHYS 523H Particle Physics II</td>
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<td>PHYS 524H Physics Laboratory IV **</td>
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<td>PHYS 525H Project **</td>
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**PHYS 526H  Special Paper (one of the following)***

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<tr>
<th>Teaching hours per week</th>
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<td>(ii) Electronics</td>
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<td>(iii) Experimental</td>
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<td>and Particle Physics</td>
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<td>(iv) Fibre Optics and</td>
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<td>Non-linear Optics</td>
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<td>(v) Informatics</td>
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<td>(vi) Nonlinear Dynamics</td>
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<td>(vii) Particle Accelerator Physics</td>
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<td>(viii) Physics of</td>
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<td>Nano-materials</td>
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<td>(ix) Science of</td>
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<td>Renewable Energy Sources</td>
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<td>(x) Advanced Statistical</td>
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<tr>
<td>Mechanics</td>
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* If a course is being taught by two teachers, they should coordinate among themselves the coverage of material as well as the assessment of the students to maintain uniformity.

+ Internal assessment in all the papers will be as per university rules and has been indicated for individual papers along with the syllabus.

** Twenty students will be allotted project (PHYS 525H) on the basis of their option and percentage of marks in M.Sc. (H.S.) I examination, while all other students will do Physics Laboratory IV (PHSY 524H).

*** The special papers will be offered depending upon the availability of teachers, and the students will be allotted one of the courses being taught, on the basis of their option and percentage of marks in M.Sc. (H.S.) I examination. Students may opt for Electronics as additional Special Paper if that is not the paper allotted to them as requirement of the degree. Marks secured in this paper will be shown on the marks card but will not be counted in determining the division.
AIMS AND OBJECTIVES OF DIFFERENT COURSES

PHYS 411H
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.

PHYS 412H
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.

PHYS 413H
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.

PHYS 414H
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.

PHYS 415H
The aim and objective of the course on **Physics 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.

PHYS 416H
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++ language so that they can use these in solving simple problems pertaining to Physics.

PHYS 421H
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.

PHYS 422H
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.
PHYS 423H
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.

PHYS 424H
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.

PHYS 425H
The aim and objective of the course on Physics 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.

PHYS 426H
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++ 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.

PHYS 511H
The aim of Classical Electrodynamics and General Theory of relativity is to understand the nature of space-time and gravity based on the Einstein’s theory of relativity. Origin of the physical inertia of matter. Applications of the special & general theory of relativity in modern physics that includes nuclear physics, particle physics and astrophysics. Covariant formulation of electrodynamics to explore the unification of electricity and magnetism. Origin of the electromagnetic radiation by an accelerating charge particle: Its applications to linear and circular accelerators. To understand the scattering of electromagnetic wave by free and bound electron. To understand why the sky is blue.

PHYS 512H
The aim and objective of the course on Condensed Matter Physics I is to expose the students of M.Sc. (H.S.) class to the topics like elastic constants, lattice vibrations, dielectric properties, energy band theory and transport theory so that they are equipped with the techniques used in investigating these aspects of the matter in condensed phase.

PHYS 513H
The aim and objective of the course on Nuclear Physics I is to familiarize the students of M.Sc. (H.S.) class to the basic aspects of nuclear physics like static properties of nuclei, radioactive decays, nuclear forces, neutron physics and nuclear reactions so that they are equipped with the techniques used in studying these things.

PHYS 514H
The aim and objective of the course on Particle Physics I is to introduce the M.Sc. (H.S.) students to the invariance principles and conservation laws, hadron-hadron interactions, relativistic kinematics, static quark model of hadrons and weak interactions so that they grasp the basics of fundamental particles in proper perspective.
**Electronics-II PHYS 515H**  
The Electronics-II course covers revisit of binary arithmetic, Logic gates, sequential and combinational circuits, Logic families and semiconductor memories, Inter-conversion of analog and digital signals, basics of integrated circuit technology, Microprocessor 8085 Architecture, instruction set, interfacing with memory and I/O devices.

**PHYS 516H**  
The aim and objective of the courses on **Physics Laboratory III** is to train the students of M.Sc. (H.S.) class to advanced experimental techniques in general physics, electronics, nuclear physics, particle physics and condensed matter physics so that they can investigate various relevant aspects and are confident to handle sophisticated equipment and analyze the data.

**PHYS 521H**  
The aim and objective of the course on **Condensed Matter Physics II** is to familiarize the M.Sc. (H.S.) students with relatively advanced topics like optical properties, magnetism, superconductivity, magnetic resonance techniques and disordered solids so that they are confident to use the relevant techniques in their later career.

**PHYS 522H**  
The aim and objective of the course on **Nuclear Physics II** is to expose the students of M.Sc. (H.S.) class to the relatively advanced topics in nuclear models and nuclear reactions so that they understand the details of the underlying aspects and can use the techniques if they decide to be nuclear physicists in their career.

**PHYS 523H**  
The aim and objective of the course on **Particle Physics II** is to expose the students of M.Sc. (H.S.) class to the relatively advanced topics like internal symmetries and quark model, details of different types of fundamental interactions and unification schemes so that they understand these aspects properly and are well equipped to pursue a career in high energy physics.

**PHYS 524H**  
The aim and objective of the courses on **Physics Laboratory IV** is to train the students of M.Sc. (H.S.) class to advanced experimental techniques in general physics, electronics, nuclear physics, particle physics and condensed matter physics so that they can investigate various relevant aspects and are confident to handle sophisticated equipment and analyze the data.

**PHYS 525H**  
The aim of the **Major project work** is to expose the students to preliminaries and methodology of research in Theoretical Physics and Experimental Physics. Students get the opportunity to participate in some ongoing research activity and development of a laboratory experiment.

**PHYS 526H(i)**  
The aim and objective of the course on **Theoretical Astrophysics** is the basic understanding of the astronomical techniques. To understand the nature and structure of the universe from terrestrial planets to galaxies. To understand the celestial phenomena related with the origin of the universe, galaxies, stars and planetary systems along with the synthesis of elements by stellar and primordial nucleosynthesis. Finally, to explore the future evolution of the universe.
PHYS 526H(ii)
The aim and Objective of the Course on **Electronics** is to expose the students of M.Sc. (H.S.) class to Advances in Microprocessors, Microcontrollers and Digital signal processing and some basics of instrumentation and interfacing techniques.

PHYS 526H(iii)
The aim and objective of the course on **Experimental Techniques in Nuclear Physics and Particle Physics** is to expose the students of M.Sc. (H.S.) class to theoretical aspects of different equipment and methods used in the fields of nuclear physics and particle physics.

PHYS 526H(iv)
The aim and objective of the course on **Fibre Optics and Nonlinear Optics** is to expose the M.Sc. (H.S.) students to the basics of the challenging research field of optical fibres and their use in nonlinear optics.

PHYS 526H(v)
The aim and objective of the course on **Informatics** is to familiarize the students of M.Sc. (H.S.) class to theoretical aspects of information technology, relevant operating systems and the C++ language.

PHYS 526H(vi)
The aim and objective of the course on **Nonlinear Dynamics** is to familiarize the M.Sc. (H.S.) students with the basics of the recently emerging research field of dynamics of nonlinear Hamiltonian systems.

PHYS 526H(vii)
The aim and objective of the course on **Particle Accelerator Physics** is to expose the M.Sc. (H.S.) students to different theoretical aspects of design and usage of various particle accelerators.

PHYS 526H(viii)
The aim and objective of the course on **Physics of Nano-materials** is to familiarize the students of M.Sc. (H.S.) to the various aspects related to preparation, characterization and study of different properties of the nanomaterials so that they can pursue this emerging research field as career.

PHYS 526H(ix)
The aim and objective of the course on **Science of renewable Energy Sources** is to expose the M.Sc. (H.S.) students to the basics of the alternative energy sources like solar energy, hydrogen energy, etc.

PHYS 526H(x)
The aim and objective of the course on **Statistical Mechanics** to expose the M.Sc. (H.S.) students to the theoretical techniques used in understanding the interacting systems, phase transitions and the non-equilibrium phenomena so that they can use these in different branches of physics, chemistry and biology.
M.Sc. (H.S.) Physics 1st Year

FIRST SEMESTER

PHYS 411H : MATHEMATICAL PHYSICS - I

Max. Marks: 15+60= 75

Note : 1. The question paper for end-semester examination will consist of seven questions of equal marks, viz. 12. The first question will be compulsory and will consist of 6-8 short questions/problems on the UGC-NET (objective type) pattern. The student is expected to provide reasoning/solution/working for the answer. The candidates will attempt five questions in all, including the compulsory question. The question paper is expected to contain problems to the extent of 40% of total marks.

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

I Complex Variables : Introduction, Cauchy-Riemann conditions, Cauchy’s Integral formula, Laurent expansion, singularities, calculus of residues, evaluation of definite integrals, Dispersion relation.

II 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 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 polynomials. Associated Legendre functions: recurrence relations, parity and orthogonality, Hermite functions, Laguerre functions.

V Elementary Statistics : Introduction to probability theory, random variables, Binomial, Poisson and Normal distribution

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

Books :

Note: 1. The question paper for end-semester examination will consist of seven questions of equal marks, viz. 12. The first question will be compulsory and will consist of 6-8 short questions/problems on the UGC-NET (objective type) pattern. The student is expected to provide reasoning/solution/working for the answer. The candidates will attempt five questions in all, including the compulsory question. The question paper is expected to contain problems to the extent of 40% of total marks.

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

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.


IV 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, Action-angle variables for systems with one-degree of freedom.

V 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, principal axis transformation, Euler equations of motion, Torque free motion of rigid body, motion of a symmetrical top.

VI Small Oscillations: Eigenvalue equation, Free vibrations, Normal Coordinates, Vibrations of a tritomic molecule.

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

Books:
Note: 1. The question paper for end-semester examination will consist of seven questions of equal marks, viz. 12. The first question will be compulsory and will consist of 6-8 short questions/problems on the UGC-NET (objective type) pattern. The student is expected to provide reasoning/solution/working for the answer. The candidates will attempt five questions in all, including the compulsory question. The question paper is expected to contain problems to the extent of 40% of total marks.

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


II Angular Momentum: Angular part of the Schroedinger equation for a spherically symmetric potential, orbital angular momentum operator. Eigenvalues and eigenvectors of \( L^2 \) and \( L_z \). Spin angular momentum, General angular momentum, Eigenvalues and eigenvectors of \( J^2 \) and \( J_z \). Representation of general angular momentum operator, Addition of angular momenta, C.G. coefficients.

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.


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

Books:
Note: 1. The question paper for end-semester examination will consist of seven questions of equal marks, viz. 12. The first question will be compulsory and will consist of 6-8 short questions/problems on the UGC-NET (objective type) pattern. The student is expected to provide reasoning/solution/working for the answer. The candidates will attempt five questions in all, including the compulsory question. The question paper is expected to contain problems to the extent of 40% of total marks.

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

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


TUTORIALS: Relevant problems given in the recommended books.
Books:


**PHYS 415H PHYSICS LABORATORY I**

Max. Marks: 30+120=150

**Note:**

1. Students are expected to perform at least 10 experiments in each semester from units 2-9 with at least one experiment from each of these units. All the contents of unit 1 are compulsory. The experiments performed in first semester cannot be repeated in second Semester.
2. The examination for both the courses will be of 4 hours duration.
3. There will be a 30 minutes written comprehensive test containing short answer questions for the whole class before the actual laboratory examination. This test will have a weightage of 25 marks in each semester, will be jointly set by the teachers involved in the examination and will be of general nature.

**Unit 1 : Introduction to experimental techniques**


**Unit 2 : Analog and Digital electronics**

1. To study the power dissipation in the SSB and DSB side bands 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.
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.

**PHYS 416H Computational Physics I**

Max. Marks: 10+40= 50


II **Programming with C++**: Introduction to the Concept of Object Oriented Programming; Advantages of C++ over conventional programming languages; Introduction to Classes, Objects; C++ programming syntax for Input/Output, Operators, Loops, Decisions, simple and inline functions, arrays, strings, pointers; some basic ideas about memory management in C++.

III **List of Numerical Problems using “Classes”**:  
1. Data handling: find standard deviation, mean, variance, moments etc. of at least 25 entries.
2. Choose a set of 10 values and find the least squared fitted curve.
3. Generation of waves on superposition like stationary waves and beats.
4. Fourier analysis of square waves.
5. To find the roots of quadratic equations.
7. Find y for a given x by fitting a set of 9 values with the help of cubic spline fitting technique.
8. Find first order derivative at given x for a set of 10 values with the help of Lagrange interpolation.
9. To generate random numbers between (i) 1 and 0, (ii) 1 and 100.
11. To find determinant of a matrix - its eigenvalues and eigenvectors.
12. Use Monte Carlo techniques to simulate phenomenon of Nuclear Radioactivity. Modify your program to a case when the daughter nuclei are also unstable.

**Books**  
SECOND SEMESTER

PHYS 421H MATHEMATICAL PHYSICS-II

Max. Marks: 15+60= 75

Note:
1. The question paper for end-semester examination will consist of seven questions of equal marks, viz. 12. The first question will be compulsory and will consist of 6-8 short questions/problems on the UGC-NET (objective type) pattern. The student is expected to provide reasoning/solution/working for the answer. The candidates will attempt five questions in all, including the compulsory question. The question paper is expected to contain problems to the extent of 40% of total marks.
2. The books indicated as text-book(s) are suggestive of the level of coverage. However, any other book may be followed.

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 C\(\text{4v}\), Topological groups and Lie groups, three dimensional rotation group, special unitary groups SU(2) and SU(3).

II Tensors: Introduction, definitions, contraction, direct product. Quotient rule, Levi-Civita symbol, Noncartesian tensors, metric tensor, Covariant differentiation. (2.6 – 2.10 of Book 2).


V Numerical Techniques: Roots of functions, Interpolation, Extrapolation, Differentiation, integration by trapezoid and Simpson’s rule, Runge Kutta method and finite difference method.

TUTORIALS: Relevant problems given in the books listed below.

Books:
Note:
1. The question paper for end-semester examination will consist of seven questions of equal marks, viz. 12. The first question will be compulsory and will consist of 6-8 short questions/problems on the UGC-NET (objective type) pattern. The student is expected to provide reasoning/solution/working for the answer. The candidates will attempt five questions in all, including the compulsory question. The question paper is expected to contain problems to the extent of 40% of total marks.
2. The books indicated as text-books are suggestive of the level of coverage. However, any other book may be followed.

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: Introduction, a dynamical model of phase transitions, Ising model in zeroth approximation.

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.

Books:
Note:
1. The question paper for end-semester examination will consist of seven questions of equal marks, viz. 12. The first question will be compulsory and will consist of 6-8 short questions/problems on the UGC-NET (objective type) pattern. The student is expected to provide reasoning/solution/working for the answer. The candidates will attempt five questions in all, including the compulsory question. The question paper is expected to contain problems to the extent of 40% of total marks.
2. The books indicated as text-book(s) are suggestive of the level of coverage. However, any other book may be followed.


II Quantum Field Theory: Resume of Lagrangian and Hamiltonian formalism of a classical field, Quantization of real scalar field, complex scalar field, Dirac field and e.m. field, Covariant perturbation theory, Feynman diagrams and their applications, Wick’s Theorem. Scattering matrix. QED.

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

Books:
PHYS 424H CLASSICAL ELECTRODYNAMICS

Max. Marks: 15+60= 75

Note:
1. The question paper for end-semester examination will consist of seven questions of equal marks, viz. 12. The first question will be compulsory and will consist of 6-8 short questions/problems on the UGC-NET (objective type) pattern. The student is expected to provide reasoning/solution/working for the answer. The candidates will attempt five questions in all, including the compulsory question. The question paper is expected to contain problems to the extent of 40% of total marks.
2. The books indicated as text-book(s) are suggestive of the level of coverage. However, any other book may be followed.

I. Electrostatics: Laplace and Poisson’s equations, Electrostatic potential and energy density of the electromagnetic field, Multipole expansion of the scalar potential of a charge distribution, dipole moment, quadrupole moment, Multipole expansion of the energy of a charge distribution in an external field, Static fields in material media, Polarization vector, macroscopic equations, classification of dielectric media, Molecular polarizability and electrical susceptibility, Clausius-Mossetti relation, Models of Molecular polarizability, energy of charges in dielectric media (Maxwell stress tensor).

II. Magnetostatics: The differential equations of magnetostatics, vector potential, magnetic fields of a localized current distribution, Singularity in dipole field, Fermi-contact term, Force and torque on a localized current distribution. (Magnetic stress tensor)

III. Boundary value problems: Uniqueness theorem, Dirichlet and Neumann Boundary conditions, Earnshaw theorem, Green’s (reciprocity) theorem, Formal solution of electrostatic boundary value problem with Green function, Method of images with examples, Magnetostatic boundary value problems.

IV. Time varying fields and Maxwell equations: Faraday’s law of induction, displacement current, Maxwell equations, scalar and vector potential, Gauge transformation, Lorentz and Coulomb gauges, Hertz potential, General expression for the electromagnetic fields energy, conservation of energy, Poynting Theorem, Conservation of momentum.

V. Electromagnetic Waves: wave equation, plane waves in free space and isotropic dielectrics, polarization, energy transmitted by a plane wave, Poynting theorem for a complex vector field, waves in conducting media, skin depth, Reflection and refraction of e.m. waves at plane interface, Fresnel’s amplitude relations, Reflection and Transmission coefficients, polarization by reflection, Brewster’s angle, Total internal reflection, Stokes’s parameters, EM wave guides, Cavity resonators, Dielectric waveguide, optical fibre waveguide, Waves in rarefied plasma (ionosphere) and cold magneto-plasma, Frequency dispersive characteristics of dielectrics, conductors and plasmas.

VI. Radiation from Localized Time varying sources: Solution of the inhomogeneous wave equation in the absence of boundaries, Fields and radiation of a localized oscillating source, electric dipole and electric quadrupole fields, centre fed antenna.

VII. Charged Particle Dynamics: Non-relativistic motion in uniform constant fields and in a slowly varying magnetic field, Adiabatic invariance of flux through an orbit, magnetic
mirroring, Cross 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.

Books :

PHYS 425H PHYSICS LABORATORY II
Max. Marks: 30+120=150

Note:
1. List of experiments is same as mentioned in PHYS 415H PHYSICS LABORATORY I Course.
2. Students are expected to perform at least 10 experiments in each semester from units 2-9 with at least one experiment from each of these units. All the contents of unit 1 are compulsory. The experiments performed in first semester cannot be repeated in second Semester.
3. The examination for both the courses will be of 4 hours duration.
4. There will be a 30 minutes written comprehensive test containing short answer questions for the whole class before the actual laboratory examination. This test will have a weightage of 25 marks in each semester, will be jointly set by the teachers involved in the examination and will be of general nature.

Unit 1 : Introduction to experimental techniques

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 semiconductor.
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.
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 & Astrophysics
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.

PHYS 426H Computational Physics II

Max. Marks:10+40=50

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
   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 E and M fields. Draw graphs in each case.
8. Use Monte Carlo techniques to simulate phenomenon of Nuclear Radioactivity. Modify your program to a case when the daughter nuclei are also unstable.
9. To study phase trajectory of a Chaotic Pendulum.
10. To study convection in fluids using Lorenz system.

Books
THIRD SEMESTER

PHYS 511H: CLASSICAL ELECTRODYNAMICS AND GENERAL THEORY OF RELATIVITY

Max. Marks : 20+80=100

Note:
1. The question paper for end-semester examination will consist of seven questions of equal marks, viz. 16. The first question will be compulsory and will consist of 6-8 short questions/problems on the UGC-NET (objective type) pattern. The student is expected to provide reasoning/solution/working for the answer. The candidates will attempt five questions in all, including the compulsory question. The question paper is expected to contain problems to the extent of 40% of total marks.
2. The books indicated as text-book(s) are suggestive of the level of coverage. However, any other book may be followed.

I Special Theory of Relativity: Lorentz transformation as orthogonal transformation in 4-dimension, relativistic equation of motion, applications of energy momentum conservation, Disintegration of a particle, C.M. System and reaction thresholds.


IV Scattering: Thomson scattering, Rayleigh scattering, absorption of radiation by bound electron.


Experimental tests: The Schwarzchild metric, precession of planetary orbits. Deflection of ray of light.

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

Books:

**PHYS 512H: CONDENSED MATTER PHYSICS-I**

Max. Marks: 15+60=75

**Note:**
1. The question paper for end-semester examination will consist of seven questions of equal marks, viz. 12. The first question will be compulsory and will consist of 6-8 short questions/problems on the UGC-NET (objective type) pattern. The student is expected to provide reasoning/solution/working for the answer. The candidates will attempt five questions in all, including the compulsory question. The question paper is expected to contain problems to the extent of 40% of total marks.
2. 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:**
PHYS 513H NUCLEAR PHYSICS-I

Max. Marks: 15+60 = 75

Note:
1. The question paper for end-semester examination will consist of seven questions of equal marks, viz. 12. The first question will be compulsory and will consist of 6-8 short questions/problems on the UGC-NET (objective type) pattern. The student is expected to provide reasoning/solution/working for the answer. The candidates will attempt five questions in all, including the compulsory question. The question paper is expected to contain problems to the extent of 40% of total marks.
2. 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:
PHYS 514H PARTICLE PHYSICS - I

Max. Marks: 15+60= 75

Note:
1. The question paper for end-semester examination will consist of seven questions of equal marks, viz. 12. The first question will be compulsory and will consist of 6-8 short questions/problems on the UGC-NET (objective type) pattern. The student is expected to provide reasoning/solution/working for the answer. The candidates will attempt five questions in all, including the compulsory question. The question paper is expected to contain problems to the extent of 40% of total marks.
2. 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, Total and Elastic cross section, 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-3 π-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 Weak Interactions: Classification of weak interactions, Fermi theory, Parity non-conservation in β-decay, experimental determination of parity violation, helicity of neutrino, K-decay, CP violation in K-decay and its experimental determination.

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

Books:
PHYS 515H ELECTRONICS-II

Max. Marks: 15+60 = 75

Note:
1. The question paper for end-semester examination will consist of seven questions of equal marks, viz. 12. The first question will be compulsory and will consist of 6-8 short questions/problems on the UGC-NET (objective type) pattern. The student is expected to provide reasoning/solution/working for the answer. The candidates will attempt five questions in all, including the compulsory question. The question paper is expected to contain problems to the extent of 40% of total marks.
2. The books indicated as text-book(s) are suggestive of the level of coverage. However, any other book may be followed.

I Digital circuits: Boolean algebra, de Morgans theorem, Karnaugh maps.
Data processing circuits: Multiplexers, Demultiplexers, Arithmetic building blocks, Encoders, Decoders, Parity generators, PLA.
Sequential circuits: Flip-Flops – RS, JK, D, clocked, preset and clear operation, race-around conditions in JK Flip-flops, master-slave JK flip-flops, Switch contact bounce circuit. Shift registers, Asynchronous and Synchronous counters, Counter design and applications.
A/D Converters: Successive approximation, Counter-type, Dual slope, voltage to frequency and voltage to time conversion techniques, accuracy and resolution.

Applications: Multiplexed displays, Frequency Counters, Time Measurement, Digital Voltmeters, ADC 0804

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

III Basic concepts of Integrated Circuits: IC technology, Fabrication of monolithic IC’s - epitaxial growth, diffusion of impurities, masking and etching; Active and Passive components, MSI, LSI and VLSI chips, FPGA.

IV 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.

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

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

Books:
Note:
1. Students are expected to perform at least 10 experiments in each semester covering all the fields. The experiments performed in third semester cannot be repeated in fourth semester.
2. The examination for both the courses will be of 4 hours duration.
3. There will be a 30 minutes written comprehensive test containing short answer questions for the whole class before the actual laboratory examination. This test will have a weightage of 25 marks in each semester, will be jointly set by the teachers involved in the examination and will be of general nature.

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 mangenate.
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.
10. Hands on experience on X-ray diffractometer for studying (i) Crystal 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.
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 $\pi\mu$ 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.
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 $\mu$Controller and universal programmer and programming for four digit seven segment multiplexed up-counter upto 9999.
40.(a) EEPROM based 8 to 3 encoder using microcontroller (b) interfacing with ADC (temperature sensor) and DAC (variable voltage source).

**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

PHYS 521H CONDENSED MATTER PHYSICS-II

Max. Marks: 20+80=100

Note:
(i) The question paper for end-semester examination will consist of seven questions of equal marks, viz. 16. The first question will be compulsory and will consist of 6-8 short questions/problems on the UGC-NET (objective type) pattern. The student is expected to provide reasoning/solution/working for the answer. The candidates will attempt five questions in all, including the compulsory question. The question paper is expected to contain problems to the extent of 40% of total marks.

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

I  Optical Properties: Macroscopic theory – generalized susceptibility, Kramers-Kronig relations, Brillouin scattering, Raman effect; interband transitions.


IV Superconductivity: Experimental Survey; Basic phenomenology; BCS pairing mechanism and nature of BCS ground state; Flux quantization; Vortex state of a Type II superconductors; Tunneling Experiments; High $T_c$ superconductors.

V Disordered Solids: Basic concepts in point defects and dislocations; Noncrystalline solids: diffraction pattern, glasses, amorphous semiconductors and ferromagnets, heat capacity and thermal conductivity of amorphous solids, nanostructures – short expose; Quasicrystals.

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

Books:
Note:
(i) The question paper for end-semester examination will consist of seven questions of equal marks, viz. 16. The first question will be compulsory and will consist of 6-8 short questions/problems on the UGC-NET (objective type) pattern. The student is expected to provide reasoning/solution/working for the answer. The candidates will attempt five questions in all, including the compulsory question. The question paper is expected to contain problems to the extent of 40% of total marks.
(ii) The books indicated as text-book(s) are suggestive of the level of coverage. However, any other book may be followed.

Review of Fermi gas model and liquid drop model.

I Shell model: Coupling of angular momenta, C.G. & Racah coefficients, Wigner’s 3j,6j and 9j symbols and properties, Extreme particle model with square-well & harmonic oscillator potentials, spin-orbit coupling, shell model predictions, static electromagnetic moments of nuclei, LS & jj coupling, seniority wave function, magnetic moment-Schmidt lines, Single particle model, Total spin ‘J’ for various configurations, electric quadrupole moment, configuration mixing, independent particle model, coefficient of fractional parentage, Two nucleon wavefunction, Matrix elements of one and two body operators, Correlation in nuclear matter.

II Collective model: Rotation-D matrices and properties, Collective modes of motion, nuclear vibrations, iso-scalar vibrations, Giant resonance, derivation of collective Hamiltonian and applications, Rotation and vibration of even-even nuclei, β and γ-vibrations, Rotational-vibrational coupling, odd-mass nuclei - coupling of particle to even-even core, Nilsson model, Rotational motion at high spin, Kinematic and dynamic moment of inertia, Routhian and alignment plots, backbending behaviour.

III Nuclear reactions: Review of Statistical and Optical model for compound nucleus, Direct reactions: Kinematics and theory of stripping, pick up and reverse reactions. Fusion-evaporation & transfer reactions and various models, Heavy-ion induced nuclear reactions and various phenomena at low, intermediate and high energies.

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

Books:
Note:
(i) The question paper for end-semester examination will consist of seven questions of equal marks, viz. 16. The first question will be compulsory and will consist of several short questions/problems covering the entire syllabus. The candidates will attempt five questions in all, including the compulsory question. The question paper is expected to contain problems to the extent of 40% of total marks.
(ii) The books indicated as text-book(s) are suggestive of the level of coverage. However, any other book may be followed.

I Review of Relativistic Quantum Mechanics and Quantum Field theory.


III Symmetries and Symmetry Breaking.
   (a) Continuous groups: U(1)~SO(2), SO(3) ~SU(2)~spin(3), SU(3) and Unitary groups. Lorentz group SO(1,3) and its representations. Dirac, Weyl and Majorana fermions.

IV Abelian and Non-Abelian gauge fields. Lagrangian and gauge invariant coupling to matter fields. Elements of Quantization and Feynman rules.


VI. QCD and quark model: Asymptotic freedom and Infrared slavery, confinement hypothesis. Approximate flavor symmetries of the QCD Lagrangian: Chiral symmetry and it’s breaking. Classification of hadrons by flavor symmetry: SU(2) and SU(3) multiplets of Mesons and Baryons.

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

Books:
PHYS 524H Physics Laboratory IV

Max. Marks: 20+80=100

Note:
1. List of experiments is same as mentioned in PHYS 516H PHYSICS LABORATORY III Course.
2. Students are expected to perform at least 10 experiments in each semester covering all the fields. The experiments performed in third semester cannot be repeated in fourth semester.
3. The examination for both the courses will be of 4 hours duration.
4. There will be a 30 minutes written comprehensive test containing short answer questions for the whole class before the actual laboratory examination. This test will have a weightage of 25 marks in each semester, will be jointly set by the teachers involved in the examination and will be of general nature.

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 thermoluminescence of F-centres in alkali halide crystals.
4. To study Raman scattering in CCl₄.
5. To study Zeeman effect by using Na lamp.
7. Hands on experience on X-ray diffractometer for studying (i) Crystal structure (ii) Phase identification and (iii) size of nanoparticles.
8. 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.
9. To measure (i) dielectric constant of solid/liquid; (ii) Q of a cavity. Use of Klystron-based microwave generator.
10. To plot polar pattern and gain characteristics of Pyramidal horn antenna and parabolic dish for microwaves.
12. Energy calibration of a gamma-ray spectrometer and determination of the energy resolution by using multi-channel analyzer.
13. To study time resolution of a gamma-gamma ray coincidence set-up.
14. To study anisotropy of gamma-ray cascade emission in ⁶⁰Ni (⁶⁰Co source) using a coincidence set-up.
15. Time calibration and determination of the time resolution of a coincidence set-up using a multi-channel analyzer.
16. To study calibration of a beta-ray spectrometer.
17. To study scattering of gamma rays from different elements.
18. To determine range of Alpha-particles in air at different pressure and energy loss in thin foils.
19. To determine strength of alpha particles using SSNTD.
20. To measure $p\beta$ of a particle using emulsion track.
21. To study p-p interaction and find the cross-section of a reaction using a bubble chamber.
22. To study n-p interaction and find the cross-section using a bubble chamber.
23. To study k-d interaction and find its multiplicity and moments using a bubble chamber.
24. To study a $\pi\mu$ event using emulsion track.
25. 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.
26. To study of Switched-mode power supply.
27. 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.
29. Computer controlled experiments and measurements (Phoenix kit and Python language) – Digital and analog measurements based experiments.
30. Control of devices and data logger using parallel port of PC – programming using Turbo C.
32. 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.
33. (a) Selection of port for I & O and generation of different waveforms (b) control of stepper motor.
34. Microcontroller kit: hardware familiarization of $\mu$Controller and universal programmer and programming for four digit seven segment multiplexed up-counter upto 9999.
35. (a) EEPROM based 8 to 3 encoder using microcontroller (b) interfacing with ADC (temperature sensor) and DAC (variable voltage source).

**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.

**PHYS 525H PROJECT WORK**

Max. Marks: 20+80=100

The aim of project work in M.Sc.(H.S.) 4th semesters is to expose some of the students (20) to preliminaries and methodology of research and as such it may consist of review of some research papers, development of a laboratory experiment, fabrication of a device, working out some problem, participation in some ongoing research activity, analysis of data, etc. Project work can be in Experimental Physics or Theoretical Physics in the thrust as well as non-thrust research areas of the department.

A student opting for this course will be attached to one teacher of the department before the end of the 3rd semester. A report of about 30 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 effort put in the execution of the project, interest shown in learning the methodology, report prepared, grasp of the problem assigned and viva-voce/seminar, etc as per guidelines prepared by the PGAPMEC.

This load (equivalent to 2 hours per week) will be counted towards the normal teaching load of the teacher.
PHYS 526H SPECIAL PAPER in FOURTH SEMESTER

Note: Student will be opting for one of the following papers.

PHYS 526H(i) ASTROPHYSICS (Special paper)  

Max. Marks: 20+80=100

Note:
(i) The question paper for end-semester examination will consist of seven questions of equal marks, viz. 16. The first question will be compulsory and will consist of several short questions/problems covering the entire syllabus. The candidates will attempt five questions in all, including the compulsory question. The question paper is expected to contain problems to the extent of 40% of total marks.
(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.
PHYS 526H(ii) ELECTRONICS (Special paper)

Max. Marks: 20+80 = 100

Note:
(i) The question paper for end-semester examination will consist of seven questions of equal marks, viz. 16. The first question will be compulsory and will consist of several short questions/problems covering the entire syllabus. The candidates will attempt five questions in all, including the compulsory question. The question paper is expected to contain problems to the extent of 40% of total marks.
(ii) The books indicated as text-book(s) are suggestive of the level of coverage. However, any other book may be followed.

Microcontrollers and embedded processors - Overview of the 8051 family, Architecture of 8051, assembly language programming, Jump, Loop and Call instructions, Instruction set, Time delay for various 8051 chips.
I/O programming, Addressing modes, Arithmatic and Logic instructions and Programs, 8051 programming in C.
8051 hardware connection and Intel HEX file, 8051 timer programming in assembly and C, Serial port programming, Interrupts programming.
LCD and Keyboard interfacing, ADC, DAC and sensor interfacing, 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.
Real Time Operating System for System Design, Multitasking System.
Introduction to Advanced Microcontrollers: PIC and ARM controllers.
Introduction to embedded system, Classification of embedded systems.

Books:
PHYS 526H(iii) EXPERIMENTAL TECHNIQUES IN NUCLEAR PHYSICS AND PARTICLE PHYSICS (Special paper)

Max. Marks: 20+80 = 100

Note:
(i) The question paper for end-semester examination will consist of seven questions of equal marks, viz. 16. The first question will be compulsory and will consist of 6-8 short questions/problems on the UGC-NET (objective type) pattern. The student is expected to provide reasoning/solution/working for the answer. The candidates will attempt five questions in all, including the compulsory question. The question paper is expected to contain problems to the extent of 40% of total marks.

(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, analog-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:

PHYS 526H (iv) : FIBRE OPTICS AND NON-LINEAR OPTICS (Special paper)
Max. Marks: 20+80 = 100

Note:
(i) The question paper for end-semester examination will consist of seven questions of equal marks, viz. 16. The first question will be compulsory and will consist of several short questions/problems covering the entire syllabus. The candidates will attempt five questions in all, including the compulsory question. The question paper is expected to contain problems to the extent of 40% of total marks.
(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-optic 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 longitudinal 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.
PHYS 526H (v) INFORMATICS (Special paper)  

Max. Marks: 20+80=100

Note:
(i) The question paper for end-semester examination will consist of seven questions of equal marks, viz. 16. The first question will be compulsory and will consist of several short questions/problems covering the entire syllabus. The candidates will attempt five questions in all, including the compulsory question. The question paper is expected to contain problems to the extent of 40% of total marks.
(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, subroutine, recursion, file access.

IV Object Oriented Programming: Classes, objects, inheritance and encapsulation, interface and implementation, reuse and extension of classes, inheritance 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:

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PHYS 526H (vi) NONLINEAR DYNAMICS (Special paper)  

Max. Marks: 20+80=100

Note:
(i) The question paper for end-semester examination will consist of seven questions of equal marks, viz. 16. The first question will be compulsory and will consist of several short questions/problems covering the entire syllabus. The candidates will attempt five questions in all, including the compulsory question. The question paper is expected to contain problems to the extent of 40% of total marks.
(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.


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

PHYS 526H (vii) PARTICLE ACCELERATOR PHYSICS (Special paper) Max. Marks: 20+80=100

Note :
(i) The question paper for end-semester examination will consist of seven questions of equal marks, viz. 16. The first question will be compulsory and will consist of several short questions/problems covering the entire syllabus. The candidates will attempt five questions in all, including the compulsory question. The question paper is expected to contain problems to the extent of 40% of total marks.
(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.


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:

PHYS 526H (viii) PHYSICS OF NANOMATERIALS (Special paper)
Max. Marks: 20+80=100

Note:
(i) The question paper for end-semester examination will consist of seven questions of equal marks, viz. 16. The first question will be compulsory and will consist of several short questions/problems covering the entire syllabus. The candidates will attempt five questions in all, including the compulsory question. The question paper is expected to contain problems to the extent of 40% of total marks.

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


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:
PHYS 526H (ix) SCIENCE OF RENEWABLE ENERGY SOURCES (Special paper)
Max. Marks: 20+80 = 100

Note:
(i) The question paper for end-semester examination will consist of seven questions of equal marks, viz. 16. The first question will be compulsory and will consist of several short questions/problems covering the entire syllabus. The candidates will attempt five questions in all, including the compulsory question. The question paper is expected to contain problems to the extent of 40% of total marks.
(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.


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:
Note:
(i) The question paper for end-semester examination will consist of seven questions of equal marks, viz. 16. The first question will be compulsory and will consist of several short questions/problems covering the entire syllabus. The candidates will attempt five questions in all, including the compulsory question. The question paper is expected to contain problems to the extent of 40% of total marks.
(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.


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:

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