M.Sc. Syllabus
Department of Physics
(2020)

Semester	Core subject with credit	Elective subject with credit
First Semester	**Theory:** PH 701C Mathematical Physics: Credit = 4 PH 702C Classical Mechanics: Credit = 4 **PH 703C Practical –I Credit = 4** {Basic Electronic Design: Credit = 2 computer programming: Credit = 2}	Elective 1 ST 704 E Basic Statistics Credit 4 (from other Department preferably from Statistics)
	CSK-II Computer Skill-II : Credit = 4 **(To be done in Computer Science/IT Department**	
Second Semester	**Theory:** PH 801C Basic Quantum Mechanics: Credit = 4 PH802C Statistical Mechanics: Credit = 4 PH 803C Basic Electronics: Credit = 4 **PH 804C** **Advanced Practical-I: Credit = 2** **Advanced Practical-II: Credit = 2**	Elective-1 PH 0805 E Microprocessor Architecture and Programming Credit = 4 **Elective-2** PH 0806E Advanced Computational Physics Credit = 4
Third Semester	**Theory:** PH 901C Electro magnetic theory and Special theory of relativity: Credit = 4 PH 902C Atomic & Molecular Physics : Credit = 4 PH 903C Advanced Quantum Mechanics: Credit = 4 **Practical** **PH 904C Advanced Practical-III:Credit = 4**	**Elective-1** PH 905E Astrophysics and Astronomy Credit = 4 **Elective-2** PH 0906E Thin-film and Nanoscience Credit = 4
Fourth Semester	**Theory:** PH 1001C Condensed Matter Physics Credit = 4 PH 1002C Advanced Electronics : Credit = 4 PH 1003C Nuclear Physics and Particle Physics: Credit = 4 **PH 1004C** Project Work: Credit = 6	**Elective-4** PH 1005 E Advanced Physics: Credit = 4

<u>First Semester</u>

<table>
<tr>
<td rowspan="2">First Semester</td>
<td>Theory:
PH 701C Mathematical Physics: Credit = 4
PH 702C Classical Mechanics: Credit = 4

PH 703C Practical –I Credit = 4
{Basic Electronic Design: Credit = 2
computer programming: Credit = 2}</td>
<td>Elective 1
ST 704 E Basic Statistics Credit 4

(from other Department preferably from Statistics)</td>
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<td colspan="2">CSK-II Computer Skill-II : Credit = 4
(To be done in Computer Science/IT Department</td>
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Mathematical Methods of Physics:

Paper: PH 0701C (Theory)
Credit = 4 Full Marks = 100 Credit = 4
(Distribution of marks: 70 (for final examination) + 30 (Internal Evaluation)
No. of Lectures required (NLP) = 50
Number of Lecture period (NLP) for each group: 25.

Group A: Mathematical Methods of Physics : - I
Marks = 50: No. of Lectures Required (NLP) = 25

Vector Spaces and Matrices: linear independence; Bases; Dimensionality; Inner product; Linear transformations; Matrices; Inverse; Orthogonal and unitary matrices; Independent elements of a matrix; Eigenvalues and eigenvectors; Diagonalization; Complete orthonormal sets of functions.

N.L.P.-05

Tensor Calculus: Cartesian tensors. Symmetric and antisymmetric tensors. Levi Vivitia tensor density. Pseudo tensors. Dual tensors. Dire4ct product and contraction. Dyads and dyadics. Covariant, Contravariant and mixed tensors. Christoffel symbols and differentiation of tensors.

N.L.P-06

Functions of a Complex variable: Complex algebra. Cauchy Reimann conditions. Cauchy's integral theorem. Cauchy's integral formula – its applications. Taylor's expansion. Analytic continuation. Laurent's expansion.

N.L.P.-10

Calculus of Residues: Singularities. Poles. Branch points. Branch cuts. Residue theorem. Principal value – its applications.

N.L.P.-04

Group B: Mathematical Methods of Physics : - II
Marks = 50: No. of Lectures Required (NLP) = 25

Group Theory: Introduction. Discrete groups. Continuous groups. Generators. SU(2), SU(3) and homogeneous Lorentz groups.

N.L.P.-5

Differential Equations: Second Order Differential Equations : Partial differential equations of theoretical physics. Separation of variables. Ordinary differential equations (ODE). Second order linear ODEs with variable coefficients. Singular points. Series solutions : Frobenius' method. Second solution.

N.L.P.-6

Nonhomogenheous equation. Green's function. Dirac delta function. Self adjoint differential equations. Eigen functions. Eigen values. Hermitian operators.

N.L.P.-2

Special Functions: Gamma functions. Incomplete Gamma functions. Bessel functions of first kind. Neumann function. Bessel function of second kind. Spherical Bessel function. Physical applications. Legendre functions. Multipole expansions; special properties.

Associated Legendre functions. Spherical harmonics. Hermite functions. Lagguerre functions. Hypergeometric functions.

N.L.P.-7

Integral Transforms: Laplace transform; First and second shifting theorems; Inverse LT by partial fractions; LT of derivative and integral of a function; Fourier series; FS of arbitrary period; Half wave expansions; Partial sums; Fourier integral and transforms; FT of delta function.

N.L.P.-5

<u>TEXT BOOKS :</u>

1. G. Arfken : Mathematical methods for physicists. Academic Press Int. Ed. 1970 [ch 4, 6-11, 13-15].
2. J. Mathews and R.L. Walker : Mathematical methods of physics. India Book House Pvt. Ltd. [ch 4, 6-9, 16, appendix].
3. Spiegel (Schaum's Outline Series) : Complex Variables
4. A.W.Joshi : Matrices and Tensors for Physicists.

<u>REFERENCE BOOKS :</u>

1. H.O. Jeffreys and Lady Jefferys : Methods of mathematical physics. Cambridge Univ. Press. 3rd ed, 1978.
2. R.V. Churchill : Complex variables and applications.
3. D.R. Halmos : Finite dimensional vector spaces.
4. C. Harper : Introduction to mathematical physics.
5. P.M. Morse and H. Feshbach : Methods of theoretical physics. Vol 1 & 2. McGraw Hil.
6. D.T. Finkbeiner : Introduction to matrices and linear trans- formations.
7. P.K. Chattopadhyay : Mathematical methods of physics. Wiley Eastern.

Classical Mechanics
PH- 0702C (Theory)
Full Marks = 100 Credit=4
(Distribution of marks: 70 (for final examination) + 30 (Internal Evaluation)
No. of Lectures required (NLP) = 50

Group A: Classical Mechanics: - I
Marks = 50: No. of Lectures Required (NLP) = 25

Preliminaries: Newtonian mechanics of single and many particle systems, conservation laws, work-energy theorem, motion of a system with variable mass.

NLP-3

Constraints; their classification, forces of constraints, generalized coordinates and generalized momentum, principle of virtual work, D'Alembert's principle, generalized force, Lagrange's equations for a conservative and non-conservative systems, applications of Lagrange's formulation to simple cases, motion of a charged particle in electromagnetic field, dissipative systems; Rayleigh dissipation function.

NLP-7

Rotating frames: Use of Lagrange's equation and expressions for inertial forces, operator relations between fixed and rotating frames of references, motion of a particle in rotating frame and calculations of pseudo forces, terrestrial and astronomical applications of Coriolis force, effect of centrifugal force on the acceleration due to gravity.

NLP-5

Rigid body motion: kinetic energy, moment of inertia tensor, angular momentum, Euler angles, motion of heavy symmetric top, Euler equations, stability conditions.

NLP-4

Hamilton's principle: techniques of the calculus of variations, Derivation of Lagrange's equations from Hamilton's principle, Extension of Lagrange's equations to non-holonomic systems, Lagrange multipliers and applications, conservation theorems and symmetry properties.

NLP-6

Group B: Classical Mechanics: - II
Marks = 50: No. of Lectures Required (NLP) = 25

Small oscillations: formulation of the problem, the eigenvalue equation, eigenvectors and their orthogonality, the principal axis transformation, frequencies of free vibrations, normal modes and normal coordinates, free vibrations of a two coupled parallel simple pendulums system, free vibration of a linear triatomic molecule.

NLP-7

Hamiltonian formulation: Legendre transformations and the canonical equations, Hamilton's canonical equations, advantage of Hamilton's formulation, symmetries and conservation laws in Hamiltonian picture, derivation of Hamilton's equations from variational principles. Principle of least action.

NLP-5

Canonical transformations: The equations of canonical transformation, infinitesimal canonical transformation, Poisson's brackets and other canonical invariants, angular momentum Poison's bracket relations,

NLP-5

Hamilton-Jacobi theory: The Hamiltom-Jacobi equation for Hamillton's principal function, Hamilton-Jacobi equation for Hamilton's characteristic function; action-angle variables.

NLP-5

Lagrangian and Hamiltonian formulation of continuous system: the transition from discrete to continuous system, the Lagrangian formulation for continuous system, the Hamiltonian formulation for continuous system, the stress energy tensor and conservation theorems, Noether's theorem.

NLP-3

Text Books:

1. H. Goldstein, C. P. Poole & J. Safko, *Classical Mechanics,* , Pearson (2012).
2. N. C. Rana & P. S. Joag, *Classical Mechanics,* Tata Mcgraw Hill (2001).
3. K. C. Gupta; Classical Mechanics of Particles and Rigid Bodies, New Age Int. Pub.
4. L. Landau & E. Lifshitz, *Mechanics*, Oxford (1981).
5. S. N. Biswas, *Classical Mechanics*, Books & Allied (P) Ltd., Kolkata (2004)
6. R.G. Takwale & P.S. Puranik; *Introduction to Classical Mechanics*, Tata Mcgraw Hill.

Practical: PH 0703C (Credit=4)

PHS 0703C (Group-A) (Credit-2)
Group B Electronics design (digital & analog)
Marks = 50: Credit = 2
No. of Lectures required (NLP) :
Practical classes:- 75

DIGITAL CIRCUIT DESIGN

Phase 1:
1. Construct a power supply of $\pm$ 12 V / $\pm$ 15 Volts using regulator ICs. Make a facility of using = +5V in the same bread board.
2. Design and implement the following LOGIC GATES using discrete components like resistance, capacitor, diodes and transistors etc.
(a) NAND (b) NOR (c) XOR (d) XNOR

Phase 2: Experiment using IC 74**

1. Implement two input OR gate using AND & NOT gates and verify the truth table.
2. Implement two input AND gate using OR & NOT gates and verify the truth table.
3. With basic gates implement two forms of XOR function and verify the truth table.
4. With basic gates implement two forms of XNOR function and verify the truth table.
5. With NAND gates only, implement two forms of XOR functions and verify the truth table.
6. With NOR gates only, implement two forms of XOR functions and verify the truth table.
7. With NAND gates only, implement two forms of XNOR functions and verify the truth table.
8. With NOR gates only, implement two forms of XNOR functions and verify the truth table.
9. Verify the Boolean expressions with truth table
(a) (A+B).(B+C).(C+A) = AB + CD +CA
(b) $A.\bar{B} + \bar{A}.B = (A + B).\overline{A.B}$
(c) (A+B).(A+ C) = A + BC

Phase 3: Experiments with Linear ICs

1. To construct and study HALF ADDER circuit using AND gate and XOR.
2. To construct and study HALF ADDER circuit using OR, AND and NOT gates.
3. To construct and study a HALF SUBTRACTOR using AND, NOT and XOR gates.
4. To construct and study a HALF SUBTRACTOR using OR, AND and NOT gates.
5. To construct a FULL ADDER using OR, AND and XOR gates.
6. To construct a FULL SUBTRACTOR using OR, AND and XOR gates.
7. To study the 4-bit PARALLEL ADDER using FULL ADDER IC.
8. To study a 4-bit SUBTRACTOR using FULL ADDER IC.
9. To study 4-bit SUBTRACTOR/ADDER using mode control.

ANALOG DESIGN

Phase 1: Using Transistor

1. Design of common emitter amplifier and study of its bandwidth.
2. Design of an emitter follower and study of its bandwidth.

Phase 2: Using Linear IC 741/536 (OPAMP):

1. Design non-inverting amplifier with gain at any desired value in between 10 to 20 and
(i) Study the frequency response curve with input voltages fixed at 200 mV, 500 mV and 1V.
(ii) Keep the frequency fixed at 100 Hz, 1 KHz and 10 KHz and study the variation of output voltage with input.
(iii) Study the gain-bandwidth product considering gains equal to 1, 10 and 20.
2. Design inverting amplifier with gain at any desired value in between 10 to 20 and
(i) Study the frequency response curve with input voltages fixed at 200mV, 500 mV and 1V.
(ii) Keep the frequency fixed at 100 Hz, 1 KHz and 10 KHz and study the variation of output voltage with input.
(iii) Study the gain-bandwidth product considering gains equal to 1, 10 and 20.

Phase 3: Using Linear IC 741/536 (OPAMP):

1. With designing details, construct and study the following first order active filters
   (i) Low-Pass.(ii) High-Pass (iii) Band-Pass (iv) Band-Reject
2. With designing details, construct and study the following first order active filters
   (i) Low-Pass.(ii) High-Pass (iii) Band-Pass (iv) Band-Reject
3. Design and construction positive and negative half wave rectifiers and study their distortion with respect to variation of input voltage and frequency.
4. Design and construction positive and negative full wave rectifiers and study their distortion with respect to variation of input voltage and frequency.

PHS 0703C Group: B (Credit=2)

Computer Programming and Numerical Analysis: (Practical)

Elements of FORTRAN language: Integer and Real arithmatics. Numerical INPUR and OUTPUT. Formatted INPUT OUTPUT and field specifications. Transfer of controls. If - GOTO statements. DO loops. Nested DO loops. Arrays, subscripted variables. DIMENSION statement. FUNCTIONS and SUBROUTINES. DATA statement. INPUT from and OUTPUT in data files. Structured FORTRAN.
With problems from set.-I to set-IX.
Total number of lectures required: 10 (theory)

Numerical Analysis: Theory: Solution of nonlinear equations; functional iteration; bisection method; secant method; Newton - Raphson method. Interpolation: Linear interpolation; Newton'e method; Lagrange's interpolation; numerical differentiation, Numerical integration, Riemann, trapezoidal and Simpson's rules; Romberg integration; Gaussian quadrature formula. Solution of linear simultaneous equations - Gauss elimination; Gauss - Jordan elimination. Matrix algebra; eigen values and eigenfunctions of matrices.
Elementary statistical estimations; frequency distribution; simple regression; linear least square fitting; correlation coefficient. Solutions of ordinary differential equations (ODE); solution of ODE as an initial value problem; Euler's method; Runga Kutta method; predictor corrector method.

Total number of lectures required: 10 (theory)

ST 704 E Basic Statistics Credit 4

(From other Department preferably from Statistics)

CSK-II Computer Skill-II : Credit = 4

(To be done in Computer Science/IT Department

Second Semester

Second Semester	**Theory:** PH 801C Basic Quantum Mechanics: Credit = 4 PH802C Statistical Mechanics: Credit = 4 PH 803C Basic Electronics: Credit = 4 **PH 804C** **Advanced Practical-I: Credit = 2** **Advanced Practical-II: Credit = 2**	Elective-1 PH 0805 E Microprocessor Architecture and Programming Credit = 4 **Elective-2** PH 0806E Advanced Computational Physics Credit = 4

<u>Basic Quantum Mechanics</u>
<u>PH-0801C</u>

Full Marks = 100 Credit = 4
(Distribution of marks: 70 (Final examination) + 30 (Internal Evaluation)

Group A
Marks = 50: No. of Lectures Required (NLP) = 25

Wave-particle duality. Uncertainty principle. Schrodinger equation, Postulates of quantum mechanics. Wave packet, Expectation value, Conservation of probability, Stationary states.

NLP= 3

Hilbert space formalism for quantum mechanics, States as vectors and dynamical variables as linear operators on vector space, Dirac notation, Linear operators, Hermitian operator, Projection operators, Unitary operators, Eigenvalues and eigen vectors of an operator. Matrix representation of Kets, Bras, Operators and Eigen value problem, Complete set of Commuting observables, Degeneracy. Commuting observable. Compatibility and Uncertainty relations between two operators.

NLP=7

Unitary transformation, Infinitesimal Unitary transformation. Basis change and transformation. Continuous bases, Coordinate and Momentum representation of wave functions. Time evolution operator. Parity operators. Schrodinger picture, Heisenberg picture. Heisenberg equation of motion.

NLP=10

Creation and Annihilation operator, Number operator. Application of operator method to solve the eigenvalue problem of linear harmonic oscillator.

NLP=5

Group B:
Marks = 50: No. of Lectures Required (NLP) = 25

Application of Schrodinger equation. Finite and infinite potential well. Symmetric potential and Parity. Spherically symmetric potentials in three dimensions. Three-dimensional square well. Schrodinger equation in spherical co-ordinates, Spherical harmonics, Radial equation, Solution in terms of Bessel functions. Rigid rotator. Free particle and its partial wave expansion. The Hydrogenic atoms.

NPL= 10

Orbital Angular momentum in spherical polar co-ordinates. Eigen values and eigenfunctions of orbital angular momentum. Ladder operators, Commutation relations. General formalism of Angular momentum. Matrix representation of Angular momentum. Spin Angular momentum and Pauli's Spin matrices

NPL=8

Approximation Methods in Quantum Mechanics: Time independent perturbation theory. Nondegenerate case, First-order and Second-order perturbations. Degenerate cases. Anharmonic oscillator. WKB approximation. Variational Method.

NPL= 7

Books:

Zettili, N., Quantum Mechanics, (John Wiley & Sons, 2001).,
A.K. Ghatak and S. Lokannathan – Quantum Mechanics
Mathews, P. M. and Venkatesan, K., Quantum Mechanics, (Tata McGraw-Hill, 2007).
Schiff, L. S., Quantum Mechanics, (Tata McGraw-Hill Education).
Cohen-Tannoudji, Quantum Mechanics - Vol 1

<u>Statistical Mechanics</u>
PH- 0802C (Theory)

Full Marks = 100 Credit = 4
(Distribution of marks: 70 (for final examination) + 30 (Internal Evaluation)
No. of Lectures required (NLP) = 50

Group A: Statistical Mechanics: - I
Marks = 50: No. of Lectures Required (NLP) = 25

Foundations of statistical mechanics; Objective of statistical mechanics, macrostates, microstates, ensembles and phase space, connection between statistics and thermodynamics, postulate of equal a priori probability, ensemble average, density distribution in phase space, counting the number of microstates in phase space.

NPL=3

Thermodynamic probability, general expression for probability of a distribution and the most probable distribution, Liouville's theorem in classical statistical mechanics, density of states and counting of number of states.

NPL=3

Microcanonical ensemble, application to ideal gas, Canonical ensemble: System in contact with a heat reservoir, canonical partition function, thermodynamics in canonical ensemble, classical ideal gas, mean values of energy and pressure, fluctuation in internal energy, entropy of classical ideal gas, entropy and probability, Helmholtz free energy, entropy of mixing and Gibbs' paradox, equipartition theorem, system of harmonic oscillators, statistics of paramagnetism.

NPL=8

Grand Canonical Ensemble: equilibrium between a system and a particle-energy reservoir, grand canonical partition function, application to ideal gas, density and energy fluctuation, calculation of entropy.

NPL=4

Formulation of Quantum Statistics: Identical particles and symmetry requirements, many-particle wave functions, macroscopic and microscopic states for quantum systems.

NPL=2

Density Matrix: Quantum Liouville's theorem, Density matrices for microcanonical, canonical and grand canonical systems, simple examples of density matrices: one electron in a magnetic field, particle in a box.

NPL=5

Group B: Statistical Mechanics-II
Marks = 50: No. of Lectures Required (NLP) = 25

Statistics of indistinguishable particles, Fermi-Dirac and Bose-Einstein distribution functions, applications of Bose-Einstein and Fermi-Dirac statistics. General equations of state for ideal quantum systems, Properties of ideal Bose gas: Photon gas, Planck's radiation law, Debye's theory of specific heat of solids, Bose-Einstein condensation.
Properties of ideal Fermi gas: thermal and electrical properties of an ideal electron gas, white dwarf and neutron stars.

NPL=10

Cluster expansion for a classical non-ideal gas, fluctuations and transport phenormena, Brownian motion and Langevin theory, motion under fluctuating force: The Fokker-Planck equation.

NPL=5

Virial equation of state, Ising model: partition function for one dimensional case, solution of Ising model in one dimension by transfer matrix method, Brag-William approximation.

NPL = 6

Phase transition: first and second order, Landau theory of phase transition, critical exponents and scaling relations, scale transformation and dimensional analysis.

NPL=4

Text Books:

1. F. Mandl, Statistical Physics.
2. F. Reif: Statistical and Thermal Physics
3. K. Huang: Statistical Mechanics
4. R. K. Pathria: Statistiacal Mechanics
5. L. Kadanoff, Statistical Mechanics.
6. R. Kubo, Statistical Mechanics.

Basic Electronics
PH- 0803C (Theory)
Full Marks = 100 Credit=4
(Distribution of marks: 70 (for final examination) + 30 (Internal Evaluation)
No. of Lectures required (NLP) = 50

Group A: Electronics: - I (Number of lecture period: 25)

Bipolar devices: Carrier concentration in intrinsic semiconductor, Fermi level in intrinsic and extrinsic semiconductor, basic semiconductor equations, volt-ampere equation in pn diode, temperature dependence of VI characteristics of pn diode, dynamic diffusion capacitance. *(Integrated Electronics: J. Millman and C Halkias)*

NPL=4

Field-effect transistor: Ideal voltage controlled current source, JFET, MESFET, MOSFET (both enhancement and depletion type), structure, volt-ampere characteristics, the DC analysis of FET, the MOSFET as a resistance, the FET as a switch, the FET as an amplifier, small signal FET model. (*Microelectronics : Millman abd Crabel***)**

NPL= 4

Microwave device: Conception of negative resistance and its significance, the Tunnel diode, Gunn diode, p-i-n diode, Avalanche photo-diode, IMPATT, TRAPATT, BARITT diodes **[***Microwave Devices and circuits: S.Y. Liao*]

NPL= 4

Photonic device: Radiative and non-radiative transitions, Optical absorption, Principle photoconductive device, *quantum efficiency* and *photoconductive gain*, LED: Commercial LED material, LED construction, response time in LED, LED drive circuitry, photodiode, photovoltaic mode and photoconductive mode, diode laser, attainment of population inversion, photo-transistors, Optical feedback, optical gain threshold current for lasing.
(*Optoelectronics – An Introduction: J. Wilson and J.F.B. Hawkes*)

NPL=4

Memory device: Definitions and characteristics of ROM, EROM, EPROM, RAM, SRAM & DRAM; NMOS inverter, propagation delay in NOMOS inverter, the NMOS logic gates, the CMOS inverter, the CMOS logic gates, CCD, introduction to magnetic, optical and ferroelectric memories.(*Microelectronics : Millman abd Grabel*)

NPL=4

Operational Amplifiers (OPAMP) applications: Butterworth active filters of first and second order, RC phase shift oscillator, multivibrators (mon-stable and astable), logarithmic and antilogarithmic amplifiers, comparator, Schmitt trigger, triangular and square wave generators, high input impedance voltmeter. (*Operational amplifier: Robert F. Coughlin and Fredrick F. Driscoll)*

NPL=4

Group B: Electronics: - II (Number of lecture period: 25)

Analog circuits: Bipolar transistor bias stabilization against variation of temperature, IC, VBE and emitter follower, hybrid-p common emitter transistor model and short circuit current gain. (*Integrated Electronics: J. Millman and C Halkias*).

NPL= 5

Feedback amplifiers: Classification of amplifiers, the feedback concept, the transfer gain with feedback, input and output resistances in the case of voltage-series-, current-series-, voltage shunt-, and current shunt negative feedback, bandwidth expansion and reduction of noise by negative feedback. (*Integrated Electronics: J. Millman and C Halkias*)

NPL = 5

Power circuits and system: Large signal amplifiers, harmonic distortion, Class A, -B and –AB operation, efficiency of class A amplifier, Class A and –B Push pull amplifiers. (*Integrated Electronics: J. Millman and C Halkias*)

NPL = 5

Power supply: Input regulation factor, output resistance, temperature coefficient; series voltage regulator preliminary and use of Darlington pair [*Integrated Electronics: J. Millman and C Halkias*]**.**

NPL =5

Communication Electronics: Basic architecture of electronic communication. Amplitude Modulation: Ordinary AM generation demodulation; Generation of DSB signal and demodulation of DSB signal; Generation of SSB signal and demodulation of SSB signal; Generation of VSB signal and demodulation of VSB signal; Frequency translation and mixing , Frequency division multiplexing (FDM). [*Analog and digital communications: H. P. Hsu*]

NPL =5

Advanced Practical I and II
PH -804C
Advanced Practical. Marks 100: Credit: 2 + 2 =4

(Distribution of marks: 70 (for final examination) + 30 (Internal Evaluation)
No. of Lectures required (NLP) = 75

Advanced Practical – I

Expt-1:
(a) Determine the reverse saturation current I_0 and material constant *n* of a given pn junction diode.
(b) Determine the temperature coefficient of Junction voltage and energy band gap for the same.

Expt-2: Determine the resistivity and band gap of semi conductor by four probe method.

Expt-3: For given LED study the following:
i) Forward voltage vs. forward current characteristics.
ii) Forward current vs. luminus intensity.
iii) Angular displacement vs. luminus intensity.

Expt-4: Determine the dielectric constant of the given samples following capacitance measurement technique.

Expt-5: Determine the curie temperature of a given ferroelectric sample using dielectric constant measurement technique.

Expt-6: Study the Hall Effect and determine:
i) Hall Voltage ii) Hall Coefficient iii) type of majority charge carriers (i.e. determine whether the semiconductor sample is of the n-type or p-type) iv) mobility of charge carrier.

Expt-7: Using Lattice Dynamics Kit
i) Study of the dispersion relation for the mono-atomic lattice-Comparison with theory.
ii) Determination of the cut-off frequency of the mono-atomic lattice.
iii) Study of the dispersion relation for the di-atomic lattice – 'acoustical mode' and 'optical mode' energy gap. Comparison with theory.

Expt-8:
i) Study the I-V characteristics of a given solar cell used as photodiode under light and dark condition.
ii) Study the fill factor of the given solar cell.
iii) Study the spectral response curve

Expt-9: For given Photodiode study the following:
i) I-V characteristics under reverse bias and constant illumination.
ii) Illumination vs. reverse current characteristics
iii) Angular displacement vs. luminous intensity under constant reverse voltage.

Expt-10: Demonstration of modulation and demodulation by fiber optics digital communication system

Expt-11: Demonstration of modulation and demodulation by fiber optics analog communication system

Expt-12: Demonstration of amplitude and frequency modulation and demodulation

Expt-13: Determination of dissociation energy of iodine using absorption spectrophotometer

Expt-14:
i) To determine λ_{max} (wavelength of maximum absorption) of a given solution using a spectrophotometer
ii) To verify Beer-Lambert's law and apply it to find the strength of unknown solution

Advanced Practical – II

Expt-1: Determine the wavelength of the wavelength and the wavelength separation of the sodium D lines using Fabry-Perot Interferometer.

Expt-2: Determine the wavelength of an unknown light using Michelson Interferometer.

Expt-3: Determine the coercivity, retentivity and saturation magnetization by the study of hysteresis curve using hysteresis loop tracer.

Expt-4: Determine the Lande g – factor for a given paramagnetic substance using electron spin resonance spectrometer.

Expt-5: Determine the dead time of a G.M. Counter using double source method.

Expt-6: G. M. Counter – a single source statistical analysis

Expt-7: Determine the resistivity and band gap of a given semi conductor by four probe method.

Paper: PH- 0805E (option 1)
Microprocessor Architecture and Programming
Credit = 4 Full Marks = 100 Credit = 4
(Distribution of marks: 70 (for final examination) + 30 (Internal Evaluation)
No. of Lectures required (NLP) = 50

Theory:

Internal microprocessor architecture, Memory mapping, Data addressing modes, Program addressing modes,Stack memory addressing modes, Data movement instructions, Arithmetic and logic instructions, Program control instructions, Assembler details, Modular programming, using the keyboard, Data conversion, Disc files, Example programs, Pin-out and the pin functions of 8085 and 8085A, clock generators(8284A), Bus buffering and latching, Bus timing, Ready and Wait states, Memory devices, Address decoding in 8085A, memory interface, Dynamic RAM, Introduction to I/O interface, I/O port address decoding, Direct Memory Access.

Practical:

Programming in 8085 assembler kit

Paper: PH- 0806E (Credit=4)
Advanced Computational Physics
Credit = 4 Full Marks = 100
(Distribution of marks: 70 (for final examination) + 30 (Internal Evaluation)
No. of Lectures required (NLP) = 50

Introduction to various open source and proprietary computational software, software licensing, installation in different operating system environment, familiarization of the different sections of a software package, navigation, help and resources, console commands, basic variables, constants and operators, running codes from console and editors, control statements, matrix operations, functions, handling format and runtime errors, basic 2D and polar plots, polynomial operations, data read and write operations, package installations, image processing, low and high pass filtering of image, addition of noise in an image, image noise reduction, edge detection, face recognition, statistical operations, basic regression analysis, definite integral, solving linear and non-linear equations, advanced plotting, Graphical User Interface (GUI), circuit simulation, symbolic mathematics, application of numerical analysis to problem solving in physics, basic modeling, basic concept of Artificial Intelligence (AI)

Third Semester

Third Semester	**Theory:** PH 901C Electro magnetic theory and Special theory of relativity: Credit = 4 PH 902C Atomic & Molecular Physics : Credit = 4 PH 903C Advanced Quantum Mechanics: Credit = 4 **Practical** **PH 904C Advanced Practical-III:Credit = 4**	**Elective-1** PH 905E Astrophysics and Astronomy Credit = 4 **Elective-2** PH 0906E Thin-film and Nanoscience Credit = 4

<u>Classical Electrodynamics and Special Relativity</u>
<u>PH-901C</u>

Full Marks = 100 Credit = 4
(Distribution of marks: 70 (for final examination) + 30 (Internal Evaluation)
No. of Lectures required (NLP) = 50

<u>Group A: Classical Electrodynamics and Special Relativity : I</u>
Marks = 50: No. of Lectures Required (NLP) = 25

Electrostatics: Multipolc expansion. Electrostatics with ponderable media. Boundary value problems. With dielectrics, Clausius-Mossoti equation, Model for molecular polarizability, Electrostatic energy for dielectric media.

NLP=7

Magnetostatics: Magnetic multipoles. Dipole-Dipole interaction. Fermi contact term.

NLP=3

Maxwell's equation(recapitulation) : Vector and Scalar Potential, Gauge Transformatiom: Lorentz and Coulomb Gauge, Poynting vector and theorem, Complex Poynting Vector. Inhomogeneous wave equation and its solution using Green's function.

NLP=6

Radiation from localized oscillating sources: Electric and Magnetic dipole radiation. Electric quadrupole radiation. Centre-fed linear antenna.

NLP=5

Magnetohydrodynamics: Basic equations, Magnetic pressure and diffusion, Pinch effect, Alfven waveas.

NLP=4

<u>Group B: Classical Electrodynamics and Special Relativity: - II</u>
Marks = 50: No. of Lectures Required (NLP) = 25

Radiation from accelerated charges: Retarded and advanced potentials. Lienard-Wiechert potentials. Radiation from uniformly moving charges and accelerated charges. Radiated power: Angular and frequency distribution; Larmor formulae. Synchrotron radiation. Bremsstrahlung. Thomson scattering. Radiation reaction and radiation damping: Abraham Lorentz method for self force.. Cerenkov radiation.

NLP=10

Special Relativity: Relativistic addition of velocity and acceleration in vectorial form, Doppl;er effect, Thomas precession, four-momentum and four force.

NLP=5

Covariant formulation: Field tensor and its dual. Four current. Lorentz covariance of Maxwell equations. Invariants. Four vector potential. Gauge transformation. Lagrangianand Hamiltonian for the Maxwell field. Noethers theorem. Energy-Momentum tensor. Lagrangian and Hamiltonian for a charged particle in external electromagnetic fields.

NLP=10

Text Books:
1. J. D. Jackson: Classical ElectrodynamicsClassical Electro
2. W. K. H. Panofsky and M. Phillips: Classical Ectricity and Magnetism
3. D. J. Griffith: Introduction to Electrodynamics

4. M. N. O. Sadiku: Elements of Electromagnetics
5. D. K. Cheng: Field and Wave Electromagnetics

References:

L. D. landau and E. M. Lifshitz: Classical theory of Fields
A. Somerfield: Electrodynamics
A. R. Smith: Static and Dynamic Electricity.
E. C. Jordan and K. G. Balmain: Electromagnetic Waves & Radiating System

Atomic and Molecular Physics
PH-902C

Full Marks = 100 Credit = 4
(Distribution of marks: 70 (for final examination) + 30 (Internal Evaluation)
No. of Lectures required (NLP) = 50

Group A: Atomic Physics
Marks = 50: No. of Lectures Required (NLP) = 25

Quantum states of one electron atoms – Atomic Orbitals – Hydrogen spectrum – Pauli's principle. Transition rates and Slection rules. Fine structure of hydrogen and alkali spectra. Quantum defect in alkali spectra.

NLP : 7

Normal and anomalous Zeeman effect – Paschen Back effect – Stark effect – Lamb shift.

NLP : 4

Two electron systems – Role of Pauli exclusion principle – Spectra of He atoms. Singlet and Triplet series. Independent particle model. Excited states.

NLP : 4

Many Electron Atoms: Equivalent and non – equivalent electrons – LS coupling and JJ coupling. Hund's rule. Hyperfine structure (qualitative) – Line broadening mechanisms (general ideas)

NLP : 5

LASERS : Spontaneous and Stimulated emission – Einstein coefficients – Population inversion. Rate equation – Threshold conduction for laser oscillation – Pumping schemes – Role of resonant cavity – Three and four level systems – He-Ne laser, CO_2 laser, Semiconductor laser, Laser induced reactions and isotope separations. LASER as a probe for studying excited states of atoms.

NLP : 5

Group B: Molecular Physics
Marks = 50: No. of Lectures Required (NLP) = 25

Molecular Structure : Born Oppenheimer approximation for diatomic molecules. Rotation and vibrations of diatomic molecules. Electronic structure of diatomic molecules. Molecular orbital method. Heitler London method.

NLP : 5

Rotational spectra : Diatomic, linear symmetric top, asymmetric top and spherical top molecules. Rotational spectra of diatomic molecules as a rigid rotor. Energy levels and spectra of non rigid rotor. Intensity of rotational lines. Isotopic effect. Stark effect and Stark modulated microwave spectrometer (qualitative).

NLP : 5

Vibrational energy of diatomic molecules. Diatomic molecule as a simple harmonic oscillator. Energy levels and spectrum. Morse potential energy curve. Molecules as vibrating rotator. Rotational - Vibrational spectrum of diatomic molecule – PQR branches. Isotopic effect. IR spectrometer (qualitative).

NLP : 5

Raman effect. Quantum theory. Molecular polarisability. Pure rotational Raman spectra of diatomic molecules. Vibration rotation Raman spectrum of diatomic molecules. Intensity alterations in Raman spectra of diatomic molecules.

NLP : 3

Mossbauer effect : Resonance fluorescence. Kramors Heisenberg formula. Mossbauer effect. Elementary theory of recoil less emission (absorption) of gamma rays. Shift and splitting of Mossbauer lines. Isomer shift. Quadrupole interactions. Magnetic hyper-fine interactions. Line broadening.

NLP : 7

TEXT BOOKS:

1. H.E.White : Introduction to Atomic Spectra –
2. B.H.Bransden and C.J.Joachain : Physics of Atoms and Molecules. Longman 1983.
3. C.N.Banwell : Fundamentals of Molecular Spectroscopy. Tata – McGraw Hill.
4. G.M.Barrow : Introduction to Molecular Spectroscopy, McGraw Hill.
5. A.K.Ghatak : Laser. Tata – McGraw Hill

REFERENCE BOOKS:

1. G.Herzberg : Molecular Spectra and Molecular Structure. Vol. . Van Nostran 1950.
2. B.W.SHore and D.H.Menzel : Principles of Atomic Spectra. John Wiley.
3. G.M.Barrow : Introduction to Molecular Spectroscopy, McGraw Hill.
4. Spectroscopy ; Vol I, II and III Walker and Straughen.
5. Molecular Spectroscopy – J.M.Hollas.

Advanced Quantum Mechanics
PH-903C (Credit=4)

Full Marks = 100
(Distribution of marks: 70 (for final examination) + 30 (Internal Evaluation)
No. of Lectures required (NLP) = 50

Group A:
Marks = 50: No. of Lectures Required (NLP) = 25

Symmetries and Conservation laws, Space translation operator and identification of momentum as generator. Hamiltonian as the generator of time translation.

Rotational Symmetries in Quantum Mechanics and Rotation operators. Generator of rotations. Review of Spin and Orbital angular momentum. Addition of Angular momentum and Clebsch Gordon Coefficients. Tensor Operators, Wigner-Eckart theorem.

Scattering Theory: Formal theory scattering amplitude, differential and total cross section, Born approximation. Scattering from spherically symmetric potential, Partial wave analysis, Phase shift, Optical theorem.

Time dependent perturbation theory: Fermi's golden rule, transition probability. Interaction picture. Induced emission and absorption of radiation. Spontaneous emission. Einstein's A and B coefficients. Adiabatic and Sudden approximation.

Group B:
Marks = 50: No. of Lectures Required (NLP) = 25

Relativistic quantum mechanics, Klein Gordon equation and its inadequacy, Dirac equation for free particles, Antiparticles, Covariant formulation, Charge and Current density, Plane wave solutions. Dirac spinor and gamma matrices, spin and magnetic moments. Negative energy states and hole theory. Charge conjugation. Hydrogen atom in Dirac theory.

Introduction to Classical relativistic field theory: Lagrangian and Hamiltonian formulation of continuous systems. Conservation Laws and Associated Symmetries: Noether's theorem., Lorentz continuous symmetry Energy momentum tensors.

Elements of Quantum field theory. Identical particles, bosons and fermions. Quantization of scalar fields, Dirac fields. Gauge Transformation, Guage symmetry and Electromagnetic fields. Discrete symmetries: Interaction Among Fields: Interaction picture, S-matrix, Wick's theorem, Feynman rules, Feynman diagrams.

Books:
Zettili, N., Quantum Mechanics, (John Wiley & Sons, 2001).,
A.K. Ghatak and S. Lokannathan – Quantum Mechanics
Mathews, P. M. and Venkatesan, K., Quantum Mechanics, (Tata McGraw-Hill, 2007).
Cohen-Tannoudji, Quantum Mechanics - Vol 1I
A. Lahiri and P. B. Pal: Quantum Field theory
L. I. Schiff: Quantum Mechanics
E. Merzbacher : Quantum mechanics
J. J. Sakurai: Advanced Quantum Mechanics
A. Messiah: Quantum Mechanics, Vol II
L. H. Ryder: Quantum Field Theory
Ashoke Das: Quantum Field theory

Advcanced Practical-III (Credit=4)
PH-904C

Full Marks = 100
(Distribution of marks: 70 (for final examination) + 30 (Internal Evaluation)

No. of Practical classes required = 150 Practical classes

Group A: Advanced practical (Digital) Marks = 50: Practical classes: 75

RS Flip-flop with and without clock pulse (NOR and NAND latch)

Gated SR Latch and edged-triggered SR Flip-flop

The D-latch: gated D-latch & edged-triggered D Flip-flop

T flip flop

JK Flip-flop/JK master-slave Flip-flop

Shift Register (SISO, SIPO, PIPO, PISO)

Ripple counter (up and down)

Parallel counter (up and down)

Decade counter (up and down)

Group B: Advanced practical (Analog) Marks = 50: Practical classes: 75

Positive and negative clipper with and without Op-Amp

Positive and negative clamper with and without Op-Amp

Zero crossing device using Op-amp

Comparator using Op-amp

Schmitt trigger using Op-amp

Triangular wave generator using Op-amp

Differentiator and Integrator using Op-amp

Logarithmic amplifier using Op-amp

Digital-to-Analog converter using Op-amp

Mono-stable and astable multi-vibrator usingOp-amp and timer IC

Text Books: As prescribed during the practical classes time to time

Paper: PH- 905E (Credit=4)
Astrophysics and Astronomy (Theory)
Credit = 4 Full Marks = 100
(Distribution of marks: 70 (Final examination) + 30 (Internal Evaluation)
No. of Lectures required (NLP) = 50

Group-A
Marks = 50: No. of Lectures Required (NLP) = 25

Astronomical Measurements: Mass, Flux, Absolute and apparent luminosity, Magnitude systems, Apparent and absolute magnitudes. Distance modulus. Color index. Parallaxes. Variable stars as distance indicator.

Astronomical Telescope: Principle and different types. Introduction to large telescopes. γ-ray telescope, X-ray telescope. UV, IR, and Radio astronomy. Mounting of Telescope. Stellar photometry: Polarimetry using CCD detector.

Astronomical Co-ordinates: Celestial sphere, Cardinal points and Great circles on the celestial sphere. Horizontal and Equatorial coordinate system, Ecliptic and Galactic system of co-ordinates.

Spectral classification of stars, Stellar atmosphere and Saha's equation; Harvard system of classification. Mass luminosity relation, Herzsprung-Russel (H-R) diagram, Empirical mass-luminosity relation. Main sequence, pre and post-main sequence stars in H-R diagram. Energy production in star.

Group-B
Marks = 50: No. of Lectures Required (NLP) = 25

Solar System: Origin and evolution of the Solar System - Physical characteristics, Rotation, Sunspots. Inner planets, Jovian planets, Dwarf planets. Minor bodies: Asteroids: classification and origin. Comets: Physical nature, classification, and origin, Oort cloud. Planetary dust and gas. Meteors and Meteorites. Exoplanets and their experimental detection methods.

Star formation in Interstellar medium (ISM), Various nebula, Hydrostatic equilibrium, Gravitational collapse, Jeans condition for Gravitational collapse, Jeans mass, Protostars, Stellar structure and Evolution.

Galaxies: Structure and evolution, The Milky way Galaxy, External Galaxies, Classification of external galaxies. Hubble's law. Hubble classification scheme: Spirals, Elliptical, Irregulars. Orbits of stars in a galaxy. Active galactic nuclei. Quasars, Blazars, Galaxy mergers.

Basic information: Degeneracy pressure in White dwarf and Neutron star. Chandrasekhar limit, Pulsars, Supernova, Black holes and types., Gamma ray bursts, Gravitational Waves, Different models of the origin and evolution of the Universe, Microwave Background radiation, Age of the Universe. Dark Matter and Dark Energy

Text Books:

Baidyanath Basu, Astrophysics, Prentical Hall.
K. D. Abhankar, Astrophysics, Orient Longman.
W. M. Smart, Text book of Spherical Astronomy.
V. A. Ambartsumyan, Theoretical Astrophysics.
K. D. Abhyankar, Astrophysics: Stars and Galaxies, Tata McGraw Hill Publication
Joseph Silk, The Big Bank: The creation and evolution of the universe.
B. Basu, T. Chatterjee, S. N. Biswas, Introduction to Astrophysics.
K R Lang, Astrophysical quantities, Springer Verlag
Melean,Electronic Imaging Astronomy, Wiley.
J. V. Narlikar, Introduction to cosmology, CUP.

Nano Science and Thin Film
PH-906E (Elective)
(Credit-4)

Group-A

Definition of nano, Scientific Revolution, Emergence and Challenges of nanoscience and nanotechnology, Influence of nano over micro/macro dimension. Size effect. Large surface to volume ratio, Delocalization of freee electrons, Optical effect. Surface effect on the properties. NLP-10

One dimensional, Two dimensional and Three dimensional nanostructured materials, Quantum Dots. Metal oxide nano particles, semiconductor nano particles, composites nano particles, mechanical-physical-chemical properties.

NLP-8

Application of nano particles: In electronics and opto electronics devices, in coating and paint technology, biological and environmental technology and drug delivery system, polymer based application.

NLP-7

Group-B

What is Thin Film and why it is important, Two dimension nano structure. Different Thin Film preparation techniques, Brief discussion on Langmuir Blodgett technique, layer-by-layer self assembled technique, Spin coating technique, vacuum deposition technique. Different characterization techniques NLP-15

Brief discussions on the application of Thin Film in different technological fields- in preparation of Light emitting diodes, in MOSFET, in Transistor and diodes, in various sensors, in gas sensor, in biological sensors and others.

NLP-10

Fourth Semester

Theory: PH 1001C Condensed Matter Physics Credit = 4 PH 1002C Advanced Electronics : Credit = 4 PH 1003C Nuclear Physics and Particle Physics: Credit = 4 **PH 1004C** Project Work: Credit = 6	**Elective-4** PH 1004 E Advanced Physics: Credit = 4

PAPER – PH-1001C (Theory)

Condensed Matter Physics

(Credit-4)
Full Marks = 100
(Distribution of marks: 70 (for final examination) + 30 (Internal Evaluation)
No. of Lectures required (NLP) = 50

Group A: Condensed Matter Physics: - I
Marks = 50: No. of Lectures Required (NLP) = 25

Crystal Physics: Crystalline solids, unit cells and direct lattice. Two and three dimensional bravis lattices, closed packed structures

NLP : 7

Interaction of X – rays with matter, absorption of X-rays. Elastic scattering from a perfect lattice. The reciprocal lattice and its applications to diffraction techniques. The Laue, powder and rotating crystal methods. Crystal structure factor and intensity of diffraction maxima. Extinctions due to lattice centering.

NLP : 4

Point defects, line defects and planar (stacking) faults. The role of dislocations in plastic deformation and crystal growth. The observation of imperfections in crystals. X – ray and electron microscopic techniques.

NLP : 3

Lattice dynamics: Vibrations of monatomic and diatomic lattices. Accoustical and Optical phonons. Quantization of lattice vibration: phonon momentum. Debye theory. Thermal expansion. Lattice theory.

NLP : 4

Lattice specific heat, Classical and Quantum mechanical approach
NLP 2

Free Electron Fermi Gas : Free electron theory of metals. Density of states. Fermi energy at finite temperature. Fermi temperature and wave vector. Electronic specific heat. Magnetoresistance. Cyclotron resonance. Hall effect. Landau levels.

NLP : 5

Group B: Condensed Matter Physics: - II
Marks = 50: No. of Lectures Required (NLP) = 25

Dielectric Functions and Ferroelectric : Dielectric functions of the electron gas. Plasmons. Electrostatics screening. Metal insulator transition. Electron electron interactions. Claussius Mossoti relation. Polarization. Ferroelectric crystals. Phase transition.

NLP : 5

Optical Processes and Excitons : Kramers Kronig relations. Interband electronic transitions and excitons. Raman effect in crystals. Energy effect in crystals. Energy loss of fast particles in a solid.

NLP : 2

Band Theory of Solids : Nearly free electron model. Energy gap. Bloch functions. Kronig Penny model. Number of states in a bond. Effective mass of an electron in a crystal. Metals, semiconductors and insulators. Tight binding approximation . Band structure in Si, Ge and alloys.

NLP : 6

Magnetic Properties : Diamagnetism. Quantum theory of paramagnetism. Cses of rare earth and iron group ions. Crystal field splitting. Paramagnetic properties of solids. Paramagnetism. Curie Weiss law. Heisenberg's theory. Saturation magnetization. Magnons. Ferromagnetic and antiferromagnetic systems. Domains. Magnetic bubble domains.

NLP : 7

Superconductivity : Meissner effect. Heat capacity. Microwave and infrared properties. Isotope effect. London's eqation. BCS theory (qualitative ideas). Flux quantization. Single particle tunneling. Josephson tunneling. High T_c superconductivity (qualitative).

NLP : 5

TEXT BOOKS :

1. C. Kittel : Introduction to Solid State Physics. Wiley Eastern Ltd. 1979.
2. Dekker : Solid State Physics.

REFERENCE BOOKS :

1. R. J. Elliot and A. F. Gibson : An introduction to Solid State Physics and its Applications.
2. A. C. Rose-Innes and E. H. Rhoderick : Introduction to Super- conductivity. Pergamon. 1969.
3. A.O.E. Animalu : Intermediate Quantum Theory of Crystal Solids. PHI. 1978.
4. J. M. Ziman : Principles of the Theory of Solids. CUP Vikas Students Edition. 1979.
5. J. D. Patterson : Introduction to the Theory of Solid State Physics. Addison Wesley. 1971.
6. C. Kittel : Quantum Theory of Solids. John Wiley. 1963.
7. N. W. Ashcroft and N. D. Mermin : Solid State Physics. CBS Publishing. 1981.
8. D. Wagner : Introduction to the Theory of Magnetism. Pergamon. 1972.
9. J. Crangle : The Magnetic Properties of Solids. Edward Arnold. 1977.
10.J. R. Scriefer : Theory of Superconductivity. Benjamin. 1964.
11.C. M. Kachhave : Solid State Physics : Tata McGraw Hill. 1990.
12.Chrisman : Solid State Physics. Addison Wesley.

Advanced Electronics
PH-1002C
(Credit-4)
Fourth Semester

Group A
Advanced Electronics: Digital
Analog to Digital Conversion: Sampling theorem (low pas signal and band pass signal), Natural sampling and flat top sampling, Signal recovery through holding, Pulse-Amplitude modulation(PAM), Pulse width Modulation (PWM), Channel BW for PAM signal, Quantization of sampled signal, Quantization error, Pulse code modulation (PCM), Differential pulse code modulation (DPCM), Delta modulation(DM), Adaptive delta modulation(ADM), CVSD, Line code and spectral shaping [Principles of communication systems: H. Taub and D. L. Schilling].

NLP = 7

Noise in Pulse-Code and Delta-Modulation systems: PCM transmission, calculation of quantization noise, the output signal-power in PCM, the effect of thermal noise, the output signal-to-noise ratio in PCM, Delta modulation(DM), quantization noise in DM, the output signal power in DM, the DM output-signal-to-quantization-noise ratio, the effect of thermal noise in Delta modulation, output signal-to-noise ratio in DM. [Principles of communication systems: H. Taub and D. L. Schilling].

NPL = 7

Digital Modulation Technique: PSK**,** BPSK, DPSK, QPSK, DCPSK, ASK, QASK, BFSK, FSK, MSK. [Principles of communication systems: H. Taub and D. L. Schilling].

NLP = 6

Simplifying Logic Circuit & Mapping & code conversion: Sum-of-product and product of sum (using De Morgan's theorem, using NAND and using NOR logics), Karnaugh Maps, Don't care combinations, Hybrid logic, Minimization of multiple output circuit, variable spacing, Quine-McClusky method, function minimization of multiple output circuits. Encoding, decoding BCD to decimal & BCD to seven-segment code. (*Digital principles: R. L. Tokheim, Schaum's Outline Series*).

NLP = 7

Registers and counters: Buffer register, data transmission shift register, serial in serial out shift register, serial in parallel out shift register, parallel in serial out shift register and parallel in parallel out shift register, bi-directional shift register, universal shift register, dynamic shift register, applications of shift registers: Up/down ripple counter, effect of propagation delay in ripple counter, up/down synchronous counter, ring counter.

NLP = 7

Mobile Radio and Satellite: Time Division Multiple Access (TDMA), Frequency Division Multiple Access (FDMA), ALOHA, Slotted ALOHA, Carrier Sense Multiple Access (CSMA), Poison distribution, protocol, Mobile network system, Cell structures, hand-off procedure and frequency reverse scheme, GSM system.
NLP = 6

Group-B
Advanced Electronics: Analog

Sweep Generators: General features of time-base signal, Methods of generating time-base waveform----exponential sweep circuit, negative resistance switches, Miller and bootstrap time-base generators. [Pulse, Digital and Switching waveforms: J. Millman H. Taub]

NLP = 5

Silicon Controlled Rectifier (SCR): The four layer diode, pnpn characteristics, V-I characteristics of three terminal SCR, SCR control circuit [pulse control, power control, over voltage protection circuit], the triac and diac.] (Integrated Electronics: J. Millman and C Halkins).

NLP= 5

Radio wave propagation and satellite communication: Ground (surface) waves, surface wave propagation-The ionosphere, space waves, tropospheric scatter propagation, extraterrestrial communications, fundamentals of satellite communication, Global Navigational Satellite Systems (GNNS), Global positioning system (GPS) [Electronic Communication Systems: Kennedy and Davis; Data communications and Networking: B. A. Forouzan]

NLP = 7

Television: Television system and standard, Scanning, blanking and synchronizing pulses, Television camera (B & W picture and colour picture), Tonal and Colour characteristics of pictures, Composite B 7 W and colour video signals, block diagram of colour TV transmitter and receiver.[Electronic communication systems: G. Kenedy].

NLP = 6

Waveguides: Reflection of waves from conducting plane, the rectangular waveguide TM and TE waves), Cylindrical waveguides (the TEM waves in coaxial line), attenuation in duides due to imperfect conductors. [Networks, lines and fields: J. D. Ryder]

NLP = 5

Fiber optic communication: fundamentals of fiber optics, different optical fiber cables: fiber characteristics and classification, fiber optic components and systems: the source, noise, response time, optical link [Electronic Communication Systems: Kennedy and Davis]

NLP = 6

Optoelectronics: Liquid crystal display dynamic scattering LCD, field effect LCD electrical characteristics of liquid crystal and numeric displays, PhotoFET, optoelectronic coupler consisting of LED and photo transistor. [Electronic Devices and Circuits: D. A. Bell].

NLP = 6

Nuclear Physics & Particle Physics
PH-1003C (Credit-4)
Full Marks = 100
(Distribution of marks: 70 (for final examination) + 30 (Internal Evaluation)
No. of Lectures required (NLP) = 50

Group A:

Marks = 50: No. of Lectures Required (NLP) = 25

Basic nuclear properties: Mass and Binding energy. Nuclear size determination from electron scattering. Nuclear radius and Charge distribution. Semi-empirical mass formula, Mass parabola. Stability of nuclei. Nuclear form factors. Magnetic dipole moment and Electric quadrupole moment, Isospin.
Bound states: Properties of deuteron, Ground state of deuteron, Excited states, Radius. Low energy neutron-proton scattering, Scattering length, Spin dependence of nuclear forces. Effective range theory. Exchange interaction and Saturation. High energy n-p scattering. Tensor forces. Meson theory of nuclear force. Yukawa interaction.
Nuclear reactions, Q-value, Direct and Compound nuclear mechanisms, Cross-section in terms of partial wave amplitude.
Nuclear models: liquid drop model, Bohr-Wheeler theory of fission. Experimental evidence of shell effects. Shell model, Spin-orbit coupling, Magic numbers. Angular momenta and Parities of nuclear ground states, Transition rates, Magnetic moments and Schmidt lines. Collective model.
Basic idea about interaction of alpha, beta and gamma rays with matter. Nuclear radiation detectors: Cyclotron, Synchrotron, Van de Graff generator, Colliding beam accelerators.

Group B:

Marks = 50: No. of Lectures Required (NLP) = 25

Nuclear decay: Gamow's theory of alpha decay; Beta decay- Neutrino hypothesis, Helicity, Fermi's theory of beta decay, Coulomb correction, Curie Plot, electron capture, total decay rates, Comparative half-lives, Allowed and Forbidden transitions, Selection rules for Fermi and Gamow-Teller transitions, Parity violation in beta decay, Wu's Experiment. Gamma decay, multiple transitions in nuclei, Angular momentum and Parity selection rules, Internal conversion, Nuclear isomerism.
Elementary Particles: Fundamental interactions, Leptons, Hadron classification, Mesons and Baryons, Isospin and hypercharge, Symmetries and Conservation laws, Quantum numbers, Strange Particles and decays. Octet and Docuplets. Gell-Mann Nishijima relation, Resonant particles. Gell Mann-Okubo mass formula for octets and docuplets, Elementary ideas of CP and CPT invariance. CP violation in K-decay, Quark model of mesons and baryons, Coloured quarks and gluons, Eightfold way of classification, Symmetry groups: SU(2) and SU(3), Color conservation.

Books:

D. C.Tayal, Nuclear Physics, (Pragati Prakashan, 2008).
S N Ghoshal, Nuclear Physics (S. Chand, 2004)
R.R.Roy and B. P.Nigam: Nuclear Physics (New Age International, 1997)
Wong, S. S. M., Introductory Nuclear Physics, 2nd edition, (Wiley-VCH, 1999).
W.S.C. Williams: Nuclear and Particle Physics
I. S. Hughes: Elementary particles
B.L. Cohen: Concepts of Nuclear Physics
Martin, B., Nuclear and Particle Physics: An Introductory, (Wiley, 2006).
F. Halgen and A. D. martin: Quarks and Leptons (John Wiley, 1984)
D. Griffith: Introduction to Elementary Particles (Academic Press, 2008).
J. M. Blatt and V. F. Weisskopf: Theoretical Nuclear Physics
Ashoke Das: Introduction to Nuclear Physics

Project Work
PAPER – PH-1004C (Project)

Credit = 6 **Full Marks = 100**

Part-1 (Credit-2)
Visit to different laboratories, institutions, industry sectors etc and submission of report.

Part-2 (Credit-4)

Work to be carried out as per the instruction of supervisor, dissertation preparation, presentation and interaction

Advanced Physics

PH-1005E (Credit=4)

Group: A
(Atmospheric Science and Solar Environment Physics)
Total marks: 25, Total lecture periods: 12

Atmospheric science **total marks= 12.5, total lecture periods: 06**
Origin and composition of the Earth's atmosphere, distribution of pressure and density, ionosphere, atmospheric electric field, magnetosphere, distribution of temperature and winds, atmosphere as a fluid and physical laws, overview of meteorological observations, surface, radar, upper-air and satellite observational techniques, introduction to Chaos dynamics
Solar environment **total marks= 12.5, total lecture periods: 06**
Structure and composition, solar rotation, the quiet Sun, sunspots, radiation characteristics, 11 year periodicity, solar flares, coronal mass ejection, prominences, calcium plages, monitoring the sun with radio emission and X-rays, solar wind, solar proton event, solar magnetic field and its variation and solar noise storms.

Group-B
(Thin Film and nano Science Group)
Total marks: 25, Total lecture periods: 13

UV-Vis absorption spectroscopy, Fluorescence spectroscopy, in-situ Brewster angle microscopy (BAM), Atomic force microscopy (AFM), Scanning electron microscopy (SEM), Fluorescence resonance energy transfer (FRET), Bio-mimetic surface.

Group-C
(Nanophysics and Nanotechnology)
Total marks: 25, Total lecture periods: 12
Different nanomaterials and their special properties. Quantum well, Quantum wire and Quantum Dots. Definition of Nanophysics, Nanotechnology: Fabrication of Nanoparticles: Bottom up and Top down approaches: Stabilization of nanoparticles.
Braggs Law, Construction of Reciprocal Lattice, X-Ray Diffractometer and its principle: Structural Characterization, Morphological analysis by electron microscopy (Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM)) and usefulness of High resolution TEM. Effect of doping on the nanomaterials and ion irradiation effect, Different Application of nanomaterials including photonics and plasmonics.

Group-D
(Introductory Theoretical Chemical Physics)
Total marks: 25, Total lecture periods: 13
Elementary idea about the approximation methods in molecular quantum mechanics: Thomas Fermi model, Hartree theory, Hartree-Fock (HF) Approximation, Roothaan equations, Configuration Interaction, Coupled-Cluster Theory.
Density functional theory : Introduction to density functional theory, early density functional theories, the H-K theorems, the Kohn-Sham approach, K-S equation, exchange-correlation functionals, Generalized Gradiant approximation (GGA), Local density Approximation (LDA), Local Spin Density Approximation (LSDA), concept of LCAO and basis set, applications and limitations of DFT. Computational algorithms and Packages related to DFT.