[CBCS BASED]

ORDINANCE, REGULATION & SYLLABUS

For

M.Sc. [Physics]

Offered by

NEHRU GRAM BHARATI

(DEEMED TO BE UNIVERSITY),
KOTWA-JAMUNIPUR-DUBAWAL
PRAYAGRAJ-221505
UTTAR PRADESH

Session:

From 2019 – 2020

POST GRADUATE -PROGRAMME

Preamble (Physics)

The P.G. syllabus is prepared on the basis of choice based credit system guide lines of UGC.

The Master of Science in Physics programme provides the candidate with knowledge, general competence and analytical skills on an advanced level which will expertise them for higher studies and research. Also this knowledge and skills will be helpful for them in industry, consultancy, and public administration. This course provides in-depth understanding of principles and concept of Physics, proficiency in experimentation to understand the theoretical and experimental dimensions of physics. The work with the Master thesis gives special expertise on research in one particular area of Physics.

(1)

Department of Physics
Nehru Gram Bharti
(A Deemed to be University)
Kotva-Jamunipur-Dubaval, Prayagraj-221505

In a meeting of the Board of Studies in Physics held on Friday, the 24th May-2019 at 03.00 PM, under the chairmanship of Professor Ram Kripal, Dean, Faculty of Science, NGB (Deemed University), Prayagraj, the proposal of CBCS syllabus of master's degree in physics was unanimously passed and same is appended as Annexure alongwith

1. Prof. Ram Kripal, Dean & Chairman, 24.5.19
2. Dr. Anoop Kumar Srivastava (HoD, Department of Physics) 24/05/19
3. Dr. A. K. Mishra, Professor, Department of Physics
4. Dr. Sunipa Som, Assistant Professor, Sunipa Som, 24.05.19
5. Prof. A. K. Rai, Deptt. Of Physics, UoA, Prayagraj
6. Prof. Ravindra Dhar, Deptt. Of Material Science, Nehru Science Centre, UoA, Prayagraj 24/5/19

NEHRU GRAM BHARATI
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29.05.2019

Minutes of meeting

A meeting of Faculty Board of Science was held on May 29th, 2019 (10:30 AM) under the chairmanship of Dean, Faculty of science at the Civil Lines Campus, NGB (DU), Prayagarj.

The following members were present at the meeting,

S. N.	Name & Designation	Post
1.	Prof. Ram Kripal, Dean Faculty of Science, NGB(DU), Prayagraj	Chairman
2.	Prof. P.K. Singh, Ex. Head, Dept of Mathematics, University of Allahabad, Prayagraj.	Member
3.	Prof. S.N. Srivastava, Dept. of Botany, NGB(DU), Prayagraj	Member
4.	Prof. A. K. Mishra, Dept. of Physics, NGB(DU), Prayagraj	Member
5.	Prof. D.P. Chaudhari, Dept. of Mathematics, NGB(DU), Prayagraj	Member
6.	Dr. Asheesh Shivam, Head, Dept. of Zoology, NGB(DU), Prayagraj	Member
7.	Dr. Anoop Kumar Srivastava, Head, Dept. of Physics, NGB(DU), Prayagraj	Member
8.	Dr. Prasant Kumar Srivastava, Head, Dept. of Chemistry, NGB(DU), Prayagraj	Member
9.	Dr. Adi Nath Upadhyay, Head, Dept. of Botany, NGB(DU), Prayagraj	Member
10.	Dr. Pawan K. Mishra, Head, Dept. of Mathematics, NGB(DU), Prayagraj	Member
11.	Dr. Rudra Prakash Ojha, Assistant Professor, Dept. of Zoology, NGB(DU), Prayagra	Member
12.	Dr. Anita Singh, Assistant Professor, Dept. of Chemistry, NGB(DU), Prayagraj	Member
13.	Dr. Sunita Som, Assistant Professor, Dept. of Physics, Prayagra	Member

Minutes

The above said committee discussed the agenda concerning the Choice Based Credit System (CBCS) Syllabus of Masters Degree Programme of Science Faculty, already passed by different Board of Studies of different department.

The Committee unanimously passed the CBCS Syllabus of M.Sc. Botany, Chemistry, Mathematics, Physics and Zoology to be effective from the session 2019-2020 as annexed herewith.

The meeting concluded with vote of thanks to the chair.

ORDINANCES AND REGULATION FOR ALL POST GRADUATE - PROGRAMMES

A. ORDINANCE

1. The Degree of Master of Arts/Science/Social Science/Commerce/Law/Teacher's Education

The Nehru Gram Bharati (Deemed to University) may confer the Degree of Mater's Programme on Such candidates who, being eligible for admission to the Post Graduate Degree Programme, have received regular instruction in the prescribed course of study, passed successfully relevant examinations and being otherwise suitable by virtue of their character, have fulfilled such other condition as may be laid down from time to time by the appropriate authorities.

2. The Curriculum and Duration Of Studies

A. (i) The Curriculum of study of the Master Degree shall comprise of courses set out in Annexure B.

(ii) The Departmental Committee shall prescribe the detailed content of various of study, if required before the beginning of each session. The Departmental Committee can make changes in the optional papers/subjects, subjects to the availability of teaching facility/ faculty.

B. The curriculum of study for the Master Degree shall be spread over four Semesters having 80 credits (each semester of 20 credits).

3. Requirement for Admission

A. Registration:

Registration

(i) Candidates of Master Degree shall first be admitted to the first semester upon the reopening of the University after summer vacation every year.

(ii)**Subsequent Registration**

A candidate, who fails to clear a regular course of study during any of the second, third and fourth semesters may be registered in the appropriate term of any subsequent year to the semester concerned but within such time as enables him, to compete the study of all semester comprising Master Degree Programme within a maximum period of four years from the date of his/her registration for the first semester.

B. Minimum Qualification For Admission

(i) Admission to the Master Degree Programme of study shall be open to those candidates who have passed the 3 Year Graduate Degree Examination of this University or such examination of any other University or Institution after Graduation under 10+2+3 pattern as recognized by the University. Admission shall be made according to merit subject to the fulfillment of eligibility requirement as determined by the University and availability of seats in the Master courses.

C. Conditions of Admission:

(i) No application for registration to the First Semester shall be entertained unless it is accompanied by:

(a) A duly migration of scholastic record of the candidate, commencing from the graduation or equivalent examination.

(b) Original migration of a candidate who has been a regular student in any Institution at any time prior to making application for registration in the Faculty.

(c) Original migration certificate if the candidate is not enrolled in this University or if enrolled, his enrollment has been cancelled. Provided that if a candidate is unable to produce any of the documents other than the marks-sheet of the graduate examination at the time of seeking admission in the concerned Faculty before admission committee, he shall undertake to submit them within one month or within such further period as the University authorities may prescribed; and the admission, if any of such candidate shall until the submission of the aforesaid documents, be deemed to be provisional.

(ii) Candidate shall give also a written undertaking to the effect that:

(a) He/She shall exclusively devote his/her time to the study of courses prescribed for Master Degree and in particular he/she shall not offer any other course leading to a degree of any description whatsoever, not shall he/she undertake any remunerative work, though with the prior permission of the Faculty, he/she may join certificate of or diploma courses in any foreign language.

(b) He/She shall abide by the provision of NGB (DU) Act, Statutes, Ordinances, Regulations and Rules that are framed or may be framed there under and the orders of Officers and authorities of the University and the concerned Faculty from time to time.

4. Fees

The students pursuing Master Degree Programme of study shall have to pay fee as may be prescribed by the University from time to time.

5. The course of study, scheme of examination, result and promotion are covered in the regulation, and are given below.

REGULATIONS

1. Master Degree Programme has been divided in fours semesters in two years, this is a full time course study. The odd semester would run between July to December and even semester between January to June. Two consecutive (one odd + one even) semester constitute one academic year.
2. There will be minimum 18 and maximum 24 papers /courses in all in the whole programme. Besides, there would also be one course on **Dissertation and Viva-Voce.**
3. The course has 4 components: Core courses, Elective course, Skill Development and Inter-disciplinary course.
4. Each Core course has equal weightage. Each core course will have 100 marks or 4 credits. Elective and Inter-disciplinary course will have 3 credits, where as Skill Developments course will have 2 credits.
5. The core courses are compulsory to all students in all four semesters. The fourth (Elective course) paper and fifth (Skill Development course) paper will be opted by the students of same Department. However, the sixth (Inter-disciplinary course

/ University elective course) paper of each semester will be opted by the students of other Departments only.

6. In the beginning of the **Se**mester III, the Department would announce the available specialization group/ course in the Elective Group to the students for the current session. The choice of elective group/course in the semester will be limited to those announced by the Department. Because of infrastructural and Faculty limitations, the Department may put a cap on the number of students in an elective group/course.
7. Each semester shall have minimum 90 teaching days, exclusion of holidays, admission and examinations.

SCHEME OF EXAMINATION

1. The evaluation scheme of examination consists of two parts: Internal Assessment (IA), Mid Semester Exam (MSE) and End Semester Examination (ESE). Internal assessment includes Assignments, Presentations, Seminars, Quizzes, Case studies, Viva, Unit test, Group activities /Discussion, etc. The internal assessment will contribute 40% and the Semester and examination will contribute 60% to the total marks. This shall apply to both types of examination system i.e., Semester- wise and Choice based credit system (CBCS) based examination.

   **Note: The ratio of internal assessment and semester and examination will be the same as determined by the University.

2. There shall be continuous assessment of the student in each course. The course instructor shall hold a maximum of three and minimum of one internal test /assignment /presentation, etc. The distribution of marks in Internal assessment will be in two parts; 20% (Mid Sem. Exam) and 20% (Assignments/Presentations/Group Discussion etc.)
3. In case of semester examination, there shall be no binding on the number of external paper setters/examiners, though in case of CBCS//CBSS system, generally the course instructor shall be the paper setter and examiner. However, the Core courses comprising **"Dissertation and Viva-Voce** " and **"Project Work and Viva-Voce**" respectively will be evaluated / examined by Board/s consisting of one external examiner and one internal examiner who shall be the Chairman of the Board. The Dissertation / Project Work and Viva-Voce shall equal weightage and would be judged separately. The remuneration for these courses would be at par with such courses been run in other Department of the University.
4. The duration of the End Semester Examination (ESE) of each course will be 3/2 Hours.

M.Sc. [Physics] (Under CBCS Pattern) (With effect from 2019-2020)

Semester I

Sl. No.	Paper	Code	Type	Title of the paper	Credit	Maximum Marks Exam.	Continuous evaluation/Internal assessment	Total Marks
1.	Paper-I	PHY-501	Core-1	MATHEMATICAL PHYSICS	03	45	30	75
2.	Paper-II	PHY-502	Core-2	CLASSICAL MECHANICS	03	45	20	75
3.	Paper-III	PHY-503	Core-3	QUANTUMMECHANICS–I	03	45	30	75
4.	Paper-IV	PHY-601/602/603	Departmental Elective-I	ELECTROMAGNETIC THEORY/ PROGRAMMING FOR NUMERICAL METHODS/ GROUP THEORY	03	45	30	75
5.	Practical-1	PHY-701	Lab-1	VIRTUAL LABORATORY EXPERIMENTS	03	45	30	75
6.	Paper-V	PHY-801	SD-1	Instrumentation	02	30	20	50
7.	Paper-VI	PHY-901	UE-1	Nanotechnology	03	45	30	75
Total					20			500

Paper-I: MATHEMATICAL PHYSICS (PHY-501)

Unit I Complex Analysis: Analytic functions, Cauchy-Riemann equations, Cauchy's theorem, Cauchy's Integral formula, Laurent series, Poles, Residue theorem, Evaluation of integrals.

Unit II Linear Differential Equations: Second order linear differential equations; Regular, regular singular and singular points; series expansion method.

Unit III Special Functions: Bessel, Legendre, Hermite and Laguerre differential equations with properties of their solutions.

Unit IV Integral transforms: Laplace transform, Fourier theorem, Fourier transforms.

Unit V Dirac delta function and Green's function: Green's function for Laplace operator, Solution of Poisson's equation, Inhomogeneous Wave equation and applications.

Text & Reference Books:

1. *Mathematical Physics byP. K. Chattopadhyay (New Age International Publishers Ltd.)*
2. *Mathematical Physics byB.S. Rajpoot (Pragati Prakashan).*
3. *Advanced Engineering Mathematics, 19/e by H.K. Dass (S. Chand)*
4. *Mathematical Methods for Physicists, 7/e byG.B. Arfken,H. Weber, F. Harris (Elesvier Publisher).*
5. *Mathematics for Physicistsby P. Dennery and A. Krzywicki (Dover Publications).*
6. *Matrices and Tensors in Physics, 3/e by A.W. Joshi (New Age International).*

7. *Complex Variables and Applications, 8/eby J.W. Brown and R.V. Churchill (McGraw-Hill Higher Education).*
8. *Schaum's Outline of Complex Variables 2/e by J. Schiller, M. R. Spiegel, Seymour Lipschutz(Tata McGraw - Hill Education).*
9. *Schaum's Outline of Vector Analysis, 2/e by M.R. Spiegel and S. Lipschutz (Tata McGraw - Hill Education).Group Theory in Physics by Wu Ki Tung (World Scientific)*

Paper-II: CLASSICAL MECHANICS (PHY-502)

Unit I: VariationalPrinciplesandLangrange'sEquations:Hamilton'sprinciple,Calculusofvariations,Langrange'sequations,ConservationTheoremsand symmetryproperties.

Unit II: HamiltonianformalismLegendretransformationsandtheHamiltonianEquations of Motion,Cyclic coordinates.

Unit III: CanonicalTransformations:Canonicaltransformations, Poisson Bracket

Unit IV: Hamilton–JacobyTheory:HamiltonianJacobyequations;HamiltonianJacobytheory,geometrical optics andwave mechanics

Unit V: Smalloscillationsandnormalmodes:Smalloscillationsaboutastableequilibrium,Normalmodesandtheirfrequencies,LangrangianandHamiltonianformalism of ClassicalFields.

Text & Reference Books:

1. *Classical Mechanicsby N.C. Rana and P.S. Joag (McGraw Hill Education, 1991).*
2. *Classical Mechanics, 2/eby J.C. Upadhyaya (Himalaya Publishing House, 2011).*
3. *Classical Mechanics, 3/e by H. Goldstein, C.P. Poole and J. Safko (Pearson, 2011)*
4. *Mechanics, 3/e by L. D. Landau, E. M. Lifshitz, E. M. Lifshitz Joint (Butterworth-Heinemann, 1976).*
5. *Introduction to Dynamics by I.C. Percival and D. Richards (Cambridge University Press, 1982).*
6. *Classical Dynamics: A Contemporary Approach by J.V. Jose and E.J. Saletan (Cambridge University Press, 1998).*
7. *A Treatise on the Analytical Dynamics of Particles and Rigid Bodies by E.T. Whittaker (Cambridge University Press, 1988).*

Paper III: QUANTUMMECHANICS–I (PHY-503)

Unit I: Dirac'sBra&KetNotations,HilbertSpace,VectorRepresentationsofStates,ProjectionOperators,ObservablesasOperators,OrthonomalityandCompletenessofStates,RelationbetweenKetandWave-functions,Wave-functions in CoordinateandMomentumRepresentations

Unit II: MatrixTheoryofHarmonicOscillator,UncertaintyRelations,Schrödinger,Heisenberg andDirac Representations.

Unit III: OrbitalAngularMomentum,AngularMomentumAlgebra,Spin,Addition of Angular Momenta

Unit IV: Clebsch-GordonCoefficients,ExplicitAdditionofAngularMomentum1/2withAngularMomenta1/2and1,SphericalHarmonicsinCentralFieldProblems, Spin-Orbit Coupling,Fine-Structure.

Unit V: Non-CovariantDerivationofLagrangianEquationsforfields,CanonicallyConjugateMomentumDensityforSchrodinger Field,QuantumConditionsbasedonCommutationRelationsandSecondQuantization,AnnihilationandCreationOperators,SecondQuantizationbasedonAnti-CommutationRelations,SimpleProblemsonAlgebraofAnnihilationandCreationOperators.

Text & References Books:

1. *Quantum Mechanics & Field Theory by B. K. Agarwal (LokbhartiPrakashan,).*
2. *Quantum Mechanicsby A. Ghatak and S. Loknathan (Macmillan, 1999).*
3. *Modern Quantum Mechanics, 2/e by J.J. Sakurai (Pearson,2010)*
4. *Introduction to Quantum Mechanics, 2/e by D.J. Griffits (Pearson, 2005).*
5. *Quantum Mechanics: Concepts and Applications, 2/e by N. Zettili (John Wiley & Sons, 2001).*
6. *Quantum Mechanics, 3/e by L.I. Schiff (Tata McGraw - Hill Education, 1949)*
7. *Quantum Mechanics, 3/e by E. Merzbacher (John Wiely& Sons,1997)*
8. *Quantum Mechanics, 2/e by K. Gottfried, T.M. Yan, Tung-Mow Yan (Springer,2008)*

9. *Feynman Lectures on Physics (Volume 3) by R.P. Feynman (Narosa, 2008)*

Paper IV, Departmental Elective, (PHY-601 to PHY-603), Elective papers:
Semester 1 , Elective 1 (PHY-601)
ELECTROMAGNETIC THEORY
Unit I Guided electromagnetic waves: Transmission Lines and Wave Guides, Modes in a rectangular wave guide, Cavity resonators.
Unit II Tensor analysis: General coordinate transformation; contravariant, covariant and mixed tensors; metric tensor; raising and lowering of indices; contraction of indices.
Unit III Minkowsky space and Lorentz transformations: Geometry of space-time in Special Relativity; Minkowsky metric; Light cone and principle of causality; Invariance of Minkowsky metric under Lorentz transformations;Lorentz group; Proper, improper and orthochronous transformations; Pseudo-tensors.
Unit IV Covariant formulation of electromagnetism: Charge-current density four- vector; Scalar and Vector potentials; Gauge invariance; Electromagnetic potential four-vector; Electromagnetic field tensor; Lorentz transformation of electric and magnetic fields; Invariants of the electromagnetic field
Unit V Electromagnetic field of a charge moving with constant velocity, Covariant form of Lorentz force law; Dynamics of charged particles in static and uniform electric fields.

Text and Reference Books:
1. *Electromagnetics, 2/e by B. B. Laud(New Age International, 1987)*
2. *Electromagnetic Theory and Radiation Systems, 2/eby E.C. Jordan & K.G. Balman (PHI Learning, 1968)*
3. *Introduction to Electrodynamics, 3/e by D.J. Griffiths (PHI Learning, 1999)*
4. *Classical Electrodynamics, 3/e by J.D. Jackson (John Wiely& Sons, 2004)*
5. *Principles of Optics, 7/e by M. Born & E. Wolf (Cambridge University Press, 1999)*
6. *An Introduction to Microwave Theory by H.A. Atwater (Krieger Pub Co., 1981).*
7. *Electronic and Radio Engineering, 4/e by F. E. Terman (McGraw-Hill, 1955)*
8. *Foundations of Electromagnetic Theory, 4/e by J.R. Reitz, F.J. Milford and R.W. Christy (Addison-Wesley, 2008).*
9. *Classical Electricity and Magnetism, 2/e by W.K.H. Panofsky and M. Phillips (Dover Publications, 2005).*

Semester 1, Elective 2 (PHY-602)
PROGRAMMING FOR NUMERICAL METHODS
Unit-I: C++ keywords: various data types, implicit conversions, for loop, while and do-while loop, break and continue statements, switch statement, if else, conditional operator, functions with default arguments, function overloading.
Unit-II: ++ and – operators, Arrays, Structures, Pointers, Compound assignment.
Unit-III: Basic concept of OOP: definition of class and object, declaration of classes and objects, simple applications.
Unit-IV: Programming in C++ for the following: Newton Raphson method, Iterative method, Integration by Trapezoidal and Simpson 1/3 rule, Interpolation, Matrix manipulations.
Unit-V: Programming in C++ for Euler's method, Runge Kutta (second order and fourth order) method, phase space trajectory, equilibrium points, stability analysis.
Text & Reference Books:
1. *Object Oriented Programming in Turbo C++ by R. Lafore (Pearson Education India)*
2. *Methods of Numerical Analysis 5/e, by S. S. Sastry (Prentice Hall India Learning Private Limited)*
3. *Handbook of Lasers by Marvin J. Weber (CRC Press LLC).*

Semester 1, Elective 3 (PHY-603)
GROUP THEORY
Unit-I: Group theory and its application: Abstract definitions: Group, Multiplication Table, Sub-groups, Isomorphism and homomorphism, complexes, Cosets and classes, Indirect-group, Direct product of groups.
Unit-II: Theory of Representation :Linear vector space, basis, matrix representation of operators, unitary space, Unitary matrices, representation of group, characters, reducible and irreducible representations, Invariant subspaces, Schur's Lemmas
Unit-III: Orthogonality theorem for irreducible representation and characters Regular representation, occurrence of, an irreducible representation in a reducible representation.

Unit-IV: Theorem for possible number of irreducible representations of a group. Direct product of representations. Relationship to Quantum mechanics: Symmetry transformations, degeneracy and invariant subspaces, projection operators, transformation of functions.
Unit-V: Applications to molecular and crystal symmetry, Fundamental point group operations and nomenclature, construction of thirty-two point groups and character tables for their irreducible representations.
Text & Reference Books:

1. *Group Theory and Quantum Mechanics by Michael Tinkham (Dover Publication).*
2. *Molecular Symmetry and Group Theory* by *Robert L. Carter (Wiley)*
3. *Group Theory and Its Applications in Physicsby Teturo Inui, Yukito Tanabe, Yositaka Onodera (Springer)*
4. *Group Theory and Its Application to Physical Problems by Morton Hamermesh (Dover Publication).*

Practical-I, (PHY-701)
VIRTUAL LABORATORY EXPERIMENTS
1. Franck-Hertz Experiment
To experimentally demonstrate the concept of quantization of energy levels according to Bohr's model of atom.
2. Seebeck Effect
To verify the relation between thermo emf of a thermocouple and temperature difference between two hot junctions.
3. Photo-Electric Effect
To understand the phenomenon photoelectric effect as a whole.
4. Quincke's Method
To determine the volume magnetic susceptibility of manganese sulphate solution at different concentrations.
5.Comparator
To study the comparator and simulate it.
6.Fluorescence
Determination of florescence quantum yield of a fluorophore.
7.PH-Effect
Demonstration of pH effect on fluorescence excitation and emission spectra of a fluorophore.

Paper-V, Skill Development(PHY-801)
Instrumentation:
Unit I: Multimeter,, The dArsonval Movement, Voltage measurement, Current measurement, Resistance measurement, Meter sensitivity,
Unit II: Vacuum tube voltmeter, Solid State multimeter, Digital multimeter,
Unit III: Cathode-ray Oscilloscope, Cathode, Ray Tube, CRO waveform. Bolack diagram of CRO, Front panel control of a General Purpose CRO, Application of CRO.
Unit IV Electronic Components., Passive components, color coding and standard resistors values, Types of Capacitors, Inductors, Active components.
Unit V: Shunt Capacitor Filter, Series Inductor filter, Choke-Input LC filter, Pi filter,

Paper -VI, University Elective Nanotechnology (PHY-901)
Unit 1 : Introduction to nanotechnology and the two approaches (bottom up and top down) followed for the synthesis of nanomaterials.
Unit 2: Synthesis methodologies: (i) Sol-gel (ii) Microemulsion (iii) CVD,PVD, molecular beam epitaxy (iv) Vapor (solution)-liquid solid growth, (VLS or SLS) (v) Spray Pyrolysis (vi) Template based synthesis (vii) Lithography
Unit 3: Various kind of Nanostructures: (i) Carbon fullerenes and CNT (ii) Metal and metal oxide nanowires (iii) self-assembly of nanostructures (iv) Core-shell nanostructures (v) Nanocomposites
Unit 4: Physical properties of nanomaterials: (i) Photocatalytic (ii) Dielectric (iii) Magnetic (iv) Optical (v) Mechanical
Unit 5: Overview of Characterization of nanomaterials

(i) X-Ray diffraction spectroscopy
(ii) Scanning electron microscopy (SEM)
(iii) Transmission electron microscopy (TEM)
(iv) UV-Visible spectroscopy, Fourier transform infrared spectroscopy

Semester II

Sl. No.	Paper	Code	Type	Title of the paper	Credit	Maximum Marks Exam.	Continuous evaluation/Internal assessment	Total Marks
1.	Paper-I	PHY-504	Core-4	SOLID STATE ELECTRONICS	03	45	30	75
2.	Paper-II	PHY-505	Core-5	STATISTICAL MECHANICS	03	45	30	75
3.	Paper-III	PHY-506	Core-6	QUANTUM MECHANICS –II	03	45	30	75
4.	Paper-IV	PHY-604/605/606	Departmental Elective-I	ATOMIC AND MOLECULAR SPECTROSCOPY/LASER FUNDAMENTALS AND APPLICATIONS/ NANOBIOTECHNOLOGY	03	45	30	75
5.	Practical-II	PHY-702	Lab-2	REAL LABORATORY EXPERIMENTS	03	45	30	75
6.	Paper-V	PHY-802	SD-1	MS EXCEL	02	30	20	50
7.	Paper-VI	PHY-902	UE-1	Liquid Crystals	03	45	30	75
Total					20			500

Semester II

Paper-1, SOLID STATE ELECTRONICS (PHY-504)

Unit I P-N Junction Diode: Rectifier with LC Filter, Electronic regulator. Bipolar Junction Transistors: h-parameters, inter conversion in different configurations, low frequency transistor amplifier, thermal stability and bias stabilization.

Unit II Field Effect Transistors: Small signal model and dynamic parameters, CS and CD amplifiers. Multistage Amplifiers: BJT at high frequencies, frequency response of gain and phase shift, frequency response of RC coupled amplifier.

Unit III Feedback Amplifiers and Oscillators: Different negative feedback amplifiers, stability and Nychist criteria , sinusoidal oscillators , phase shift and Wien's bridge oscillators, Crystal oscillator, astablemultivibrator.

Unit IV Power and Radio Frequency Amplifier: Large signal amplifier and distortions, push-pull amplifier, single and double tuned amplifiers.

Unit V Modulation: Frequency and phase modulation, frequency modulation Demodulation: Frequency changing and tracking; AGC, AFC, FM detection, amplitude limiter, phase discriminator, ratio detector.

Text & Reference Books:

1. *Hand Book of Electronics, 38/e by S. L. Gupta & V. Kumar (Pragati Prakashan).*
2. *Electronic Device & Circuits, 3/e by J. Milliman & C.C. Halkias (McGraw-Hill).*
3. *Modern Digital Electronics 4/e by R.P. Jain (Tata McGraw - Hill Education).*
4. *Electronic Device & Circuits by A. Mottershead (PHI Learning).*
5. *Principles of Communication Systems, 2/e by H. Taub & D. Schilling (McGraw-Hill).*
6. *Electronic Fundamentals and Applications, 5/e by J.D. Ryder (PHI Learning).*
7. *Digital Integrated Electronics by H. Taub & D. Schilling (McGraw-Hill).*
8. *Digital Principles and Applications by A.P. Malvino& D.P. Leach (McGraw-Hill).*
9. *Digital Logic and Computer Design by M. Morris Mano (PHI Learning).*
10. *Microelectronics by J. Millman and A. Grabel (McGraw-Hill).*

Paper-2, STATISTICAL MECHANICS (PHY-505)

Unit I A review of Gibbs ensembles, Partition function for Perfect Gas and ensemble of Harmonic Oscillators, Partition Function for Gases containing Monoatomic, Diatomic and Polyatomic Molecules. Grand partition function,

Unit II Grand potential, FD and BE distribution in Grand Canonical ensemble Degenerate Bose Gas, Momentum Condensation, Liquid He II, Two fluid theory, Superfluidity.

Unit III Degenerate FD Gas, Conduction Electrons in a Metal, Fluctuations, One dimensional Random walk, Gaussian Distribution, Fluctuation in energy in canonical ensemble and concentration in Grand Canonical ensemble.

Unit IV Random processes, Markoff process, Langevin Equation, Correlation functions, Fluctuations Dissipation Theorem, Weiner-Khintchine theorem, Nyquist theorem,

Unit V Conditional probability, Fokker Plank Equation, Brownian motion.

Text & Reference Books:

1. *Statistical Mechanics, 3/e by B. K. Agarwal & M. Eisner (New Age International (p) Limited, 2013).*
2. *Fundamentals of Statistical Mechanics, 2/e by B. B. Laud (New Age International Publishers Ltd.-New Delhi, 2012).*
3. *Elementary Statistical Physics by C. Kittel (Dover Publications, 2008).*
4. *Statistical Mechanics, 3/e by R.K. Pathria& P.D. Beale (Elsevier, 2011).*
5. *Statistical Physics by C. Hermann (Springer, 2005).*
6. *Berkeley Physics Course, Vol 5: Statistical Physics by F. Rief (McGraw-Hill, 2008).*
7. *Statistical Physics by L.D. Landau and E.M. Lifshitz (Pergamon Press, Oxford).*

Paper-III, QUANTUM MECHANICS-II (PHY-506)

Unit I Time-Independent Perturbation Theory and Applications, Variational Method, WKB Method,

Unit II Time-Dependent Perturbation Theory, Constant and Harmonic Perturbation, Transition probabilities, Fermi's Golden Rule, Semi- Classical Theory of Radiation, Einstein A and B Coefficients, Selection Rules, Scattering,

Unit III Method of Partial Waves, Phase-Shifts, Born Approximation, Simple Applications.

Unit IV Klein Gordon Equation and Free Particle, Solution, Dirac Equation, Dirac Matrices, Covariance of Dirac Equation & Bilinear Covariants,

Unit V Solution for a Free Particle, Negative Energy states and Hole Theory, Spin, Position Operator.

Text & Reference Books:

1. *Quantum Mechanics & Field Theory by B. K. Agarwal (LokbhartiPrakashan).*
2. *Quantum Mechanicsby A. Ghatak and S. Loknathan (Macmillan).*
3. *Introduction to Quantum Mechanics, 2/e by D.J. Griffits (Pearson).*
4. *Quantum Mechanics: Concepts and Applications, 2/e by N. Zettili (John Wiley & Sons).*
5. *Mordern Quantum Mechanics, 2/e by J. J. Sakurai (Pearson Education India).*
6. *Quantum Mechanics, 3/e by L.I. Schiff (Tata McGraw - Hill Education)*
7. *An Introduction to Relativistic Quantum Mechanics & Field Theory by S.S. Schweber (Dover Publications).*
8. *Relativistic Quantum Mechanics, 1/e by S.D. Drell and J.D. Bjorken (Tata McGraw - Hill Education).*
9. *Theory of Quantized Field by P. Roman*
10. *Quantum Mechanics by E. Merzbacher(John Wiely& Sons)*
11. *Quantum Mechanics, 2/e by K. Gottfried, T.M. Yan, Tung-Mow Yan (Springer)*
12. *Feynman Lectures on Physics (Volume 3) by R.P. Feynman (Narosa)*

Paper 4, SEMESTER II, Departmental ELECTIVE (PHY-604 to PHY-606)

Sem. II, Elective 1 (PHY-604)

ATOMIC AND MOLECULAR SPECTROSCOPY

Unit-I: Atomic Spectroscopy-I

Review of He atom, ground state and first excited state, Quantum states of an electron in an atom, Spectrum of Hydrogen and Helium atom, fine structure, Spectra of Alkali atoms; energy level diagrams. Sharp, Principal, Diffuse and fundamental series,

Unit-II: Atomic Spectroscopy-II

Width of spectral lines, Spectroscopic terms; LS & JJ couplings, Hyperfine structure, Zeeman, Paschen Back & Stark effect, X-ray spectroscopy(Characteristic and continuous).

Unit-III: Microwave Spectroscopy of Diatomic Molecules

Rotational Spectra (Rigid rotator and Non-Rigid Rotator Models), Isotopic Effect in Rotational Spectra, Symmetric and Asymmetric Top Molecules, Microwave Spectrometer), Chemical Analysis by Microwave Spectroscopy, The Microwave Oven.

Unit-IV: Infra-red Spectroscopy of Diatomic Molecules

Vibrational Spectra (Harmonic and Anharmonic models), Selection rules, Term Schemes, Molecular Symmetric Top, Vibrating Rotator, Isotopic Shift, Infra-red (IR) Spectrophotometer, Fourier Transform Infra-red (FTIR) Spectroscopy and Applications.

Unit-V: Raman and Electronic Spectroscopy of Diatomic Molecules

Raman Spectra (Quantum Mechanical and Classical Approach), Structure Determination from Raman and IR Spectroscopy, Techniques and Instrumentation (Raman Spectrometer), Near Infra-red FT-Raman Spectroscopy. Electronic Spectra-Vibrational Structure of Band System, Fine Structure of the Band Systems, Intensity Distribution in Band Systems: Frank Condon principle, Techniques and Instrumentation (Photoelectron Spectrometer).

Text & Reference Books:

1. *Atomic and Molecular Spectra by Raj Kumar (Kedar Nath Ram Nath).*
2. *Molecular Structure and Spectroscopy by G. Aruldhas (PHI Learning).*
3. *Introduction to Atomic Spectra by H. E. White (McGraw-Hill).*
4. *Molecular Spectra and Molecular Structure, Vol I: Spectra of Diatomic Molecules by G. Herzberg (Krieger Publishing Company).*
5. *Fundamental of Molecular Spectroscopy,4/e by C. N. Banwell (McGraw-Hill)*
6. *Atoms and Molecules: An Introduction for Students of Physical Chemistry by M. Karplus and R.N. Porter (Benjamin–Cummings Publishing Company).*

Sem. II, Elective 2 (PHY-605)

LASER FUNDAMENTALS AND APPLICATIONS

Unit-I: Properties of Lasers & Einstein Coefficients and Light Amplification

Laser Beam Characteristics, Coherence Properties of Laser Light, Temporal, Spatial Coherence. The Einstein Coefficients: Absorption and Emission Cross Sections, Light Amplification, The Threshold Condition, Line Broadening Mechanisms (Natural, Collision, Doppler Broadening), Saturation Behavior of Homogeneously and Inhomogeneously Broadened Transitions, Quantum Theory for the Evaluation of the Transition Rates and Einstein Coefficients, More Accurate Solution for the Two-Level System.

Unit-II: Laser Rate Equation & Optical Resonators

*Laser Rate equation, Two-Level System, Three-Level Lase*r System, The Four-Level Laser System, Variation of Laser Power around Threshold, Optimum Output. Optical Resonators: Modes of a Rectangular Cavity and the Open Planar Resonator, Spherical Mirror Resonators, The Quality Factor, The Ultimate Linewidth of a Laser, Mode Selection (Transverse and Longitudinal Mode Selection), Pulsed Operation of Lasers, Q-Switching, Techniques for Q- Mode Locking, Modes of Confocal Resonator System, Modes of a General Spherical Resonator.

Unit-III: Some Laser Systems

Ruby Lasers, Neodymium-Based Lasers, Nd:YAG Laser, Nd:Glass, Titanium Sapphire Laser, The He–Ne Laser, The Argon Ion Laser, The CO2 Laser, Dye Lasers, Semiconductor Lasers. Optical Parametric Oscillators: Introduction, Optical Non-linearity, Parametric Amplification, Singly Resonant Oscillator, Doubly Resonant Oscillator, Frequency Tuning, Phase Matching.

Unit-IV: Application of Laser in Light Wave Communications

Carrier Wave Communication, Analog Modulation, Digital Modulation, Optical Fibers in Communication, The Optical Fiber, Why Glass Fibers?, Attenuation of Optical Fibers, Aperture of the Fiber, Multimode and Single-Mode Fibers, Single-Mode Fiber, Spot Size of the Fundamental Mode, Pulse Dispersion in Optical Fibers.

Unit-V: Application of Laser in Science & Industry

Second-Harmonic Generation Stimulated Raman Emission, Intensity-Dependent Refractive, Lasers in Chemistry, Lasers and Ether Drift, Lasers and Gravitational Waves, Rotation of the, Photon Statistics, Lasers in Isotope Separation. Applications in Material Processing: Laser Welding, Hole Drilling, Laser Cutting. Other Applications: Laser Tracking, Lidar. Lasers in Medicine. Precision Length Measurement Laser Interferometry and Speckle. Speckle Metrology. Velocity Measurement: Lasers in Information Storage, Bar Code Scanner.

Text & Reference Books:

1. *Lasers:Fundamentals and Applications by K. Thyagarajan and AjoyGhatak (Springer US)*
2. Basics of Laser Physics by Karl F. Renk (Springer-Verlag Berlin Heidelberg)

3. *Principles of Lasers by OrazioSvelto(Springer US)*
4. *Principle of Lasers and Optics by Willium S.C. Chang (Cambridge University Press)*
5. *Handbook of Lasers by Marvin J. Weber (CRC Press LLC).*
6. *Fundamentals of Light Sources and Lasers byMark Csele (Published by John Wiley & Sons, Inc., Hoboken, New Jersey).*

Sem. II, Elective 3 (PHY-606)
NANOBIOTECHNOLOGY

Unit-I: Biological Nano-Objects

Structural and Functional Regulation of DNA: Geometry, Topology and Methylation : Geometry of the DNA Double Helix - The Z Conformation of DNA.- Supercoiled DNA - Methylation of DNA - Protein–Lipid Assembly and Biomimetic Nanostructures : Introduction: Biological Membranes - Lipid Membranes: Structure and Properties - Models and Methods for Characterising Membranes - Protein–Lipid Assembly - Applications of Biomimetic Membranes

Unit-II: Functionalized Inorganic Nanoparticles FOR Biomedical Applications and Living Machines

Synthesis and Chemical Surface Modification of Inorganic Nanoparticles – Biological Tagging in Vitro and in Animals - *In-Vivo* Applications - Living Nanomachines: Introduction - Force and Motion by Directed Assembly of Actin Filaments - Molecular Motors: Myosins and Kinesins - ATP Synthase.

Unit-III: Methods of Nanobiotechnology

Optical tools – Nanoforce and imaging – Surface methods – Mass spectrometry – Electrical Characterization and Dynamics of Transport – Microfludics : Concepts and Applications to the Life Sciences.

Unit-IV: Applications of Nanobiotechnology

Real Time PCR – Biosensors : From the Glucose electrode to the Biochip – DNA Microarrays – Protein Microarrays – Cell Biochips – Lab on a chip – Polyelectrolyte multilayers – Biointegrating materials – Pharmaceutical applications of nanoparticles carriers.

Unit-V: Major Physiologic Systems of Current Interest to Biomedical Engineers

Cardiovascular, endocrine, nervous, visual, auditory, gastrointestinal, and respiratory. Useful definitions. The status of tissue engineering of specific organs, including bone marrow, skeletal muscle, and cartilage. Cell biological fundamentals of tissue engineering. Nanoparticle-biomaterial hybrid systems Biomaterial based metallic nanowires, networks.

Text & Reference Books:

1. *Nanoscience : Nanobiotechnology and Nanobiology, P. Boisseau, P. Houdy and M. Lahmani, Springer, 2007.*
2. *Handbook of Nanostructured Biomaterials and Their Applications in Nanobiotechnology, Hari Singh Nalwa, American Scintific Publishers, 2005.*
3. *Nanobiotechnology, C.M.Niemeyer, C.A. Mirkin, Wiley VCH, 2004.*
4. *Nanocomposite Science & Technology, Ajayan, Schadler& Braun, Wiley VCH, 2005.*
5. *Nanoelectronics and Nanosystems: From Transistors to Molecular Devices, K.Goser, P. Glosekotter, J. Dienstuhl, Springe, 2004.*
6. *Nanotechnology: Basic Science and Emerging Technologies, Mick Wilson, KamaliKannangara, Geoff Smith, Michelle Simmons, Burkhard Raguse, Overseas Press, 2005.*

Practical-II, Semester 2 (PHY-702)
REAL LABORATORY EXPERIMENTS

1. Forbidden Energy Band
2. Botzmann constant
3. Capacity and Permittivity
4. Curie Temperature
5. Modulation and Demodulations
6. Energy Band Gap of Si & Ge Diodes
7. Double Stage Amplifier
8. Design of CE Amplifier
9. Design of Regulated Power Supply

Paper V: Skill Development,MS EXCEL,(PHY-802)

Unit I: Mathematical calculation: Basic understanding, Addition Subtraction, Multiplication Division.
Unit II: Single x single y data Graph plotting, Single x multiple y date graph plotting, Double x vs y data graph plotting

Unit III: Labelling of x and y exes, labelling of data point in graph.
Unit IV: Graph plotting for given equation such as linear, polynomial, quadratic, Parabola, Circle or any given function.
Unit V: Curve fitting and analysis of linear, polynomial, exponential or any given function.

Paper 6, University Elective, Liquid Crystals (PHY-902)
Unit 1 Various meso phases, Nematic, Smectic, Cholesteric, Ferro and anti ferro electric liquid crystals, Polymer dispersed liquid crystals.
Unit II: Effect of Electric Field on Liquid Crystals in planar aligned cells, Effect of electric field on Liquid Crystals for homeotropic aligned cells,
Unit III:Flexoelectric effect, Flexoelectric effect, Surface-stabilized ferroelectric liquid crystals.
Unit IV, Freedericksz transition Statics, Splay geometry, Bed geometry, Twist geometry, TwistedNematic cell Splay geometry with weak anchoring, Splay geometry with pretilt angle.
Unit V: Liquid Crystal Materials Refractive indices, Dielectric constants, Rotational viscosity, Elastic constants

Semester III

Sl. No.	**Paper**	**Code**	**Type**	**Title of the paper**	**Credit**	**Maximum Marks Exam.**	**Continuous evaluation/Internal assessment**	**Total Marks**
1.	Paper-I	PHY-507	Core-10	CONDENSED MATTER PHYSICS	03	45	30	75
2.	Paper-II	PHY-508	Core-11	NUCLEAR PHYSICS	03	45	30	75
3.	Paper-III	*PHY-607/609/611	*Departmental Elective-**I:** Nanoscience and Nanotechnology **Elective-II**: Laser and Spectroscopy **Elective-III:** Electronics	INTRODUCTION TO NANOSCALE SCIENCE AND TECHNOLOGY/ Laser and Spectroscopy/ ANALOG AND DIGITAL ELECTRONICS/	03	45	30	75
4.	Paper-IV	*PHY-608/610/612	*Core-12 (**Specialization-I:** Nanoscience and Nanotechnology **Specialization-II**: Laser and Spectroscopy **Specialization-III:** Electronics	SYNTHESIS AND CHARACTERIZATION OF NANOMATERIALS/ELECTRONIC SPECTRA OF DIATOMIC MOLECULE /Microwaves/	03	45	30	75
5.	Practical-III	PHY-703/704/	Special subject	Nanoscience and Nanotechnology/ Laser	03	45	30	75

		705	practical	Spectroscopy /Electronics				
6.	Paper-V	PHY-803	SD-1	Origin	02	30	20	50
7.	Paper-VI	PHY-903	UE-1	Electric and Magnetic Properties	03	45	30	75
Total					20			500

***In Semester III, the choice of 4th paper will be based on departmental elective paper. The details are given below**

In Sem. III,

IfStudent's elected 3rd paper of"INTRODUCTION TO NANOSCALE SCIENCE AND TECHNOLOGY", then the corresponding 4th paper will be SYNTHESIS AND CHARACTERIZATION OF NANOMATERIALS. If elected 3rd paper : "LASER SPECTROSCOPY" then corresponding 4th paper will be "ELECTRONIC SPECTRA OF DIATOMIC MOLECULE"**. If elected 3rd paper : "**ANALOG AND DIGITAL ELECTRONICS**" then corresponding 4th paper will be "**MICROWAVES"

Paper - I CONDENSED MATTER PHYSICS (PHY-507)

Unit I Electron band theory: one electron band theories. Plane wave like and localized wave functions. Nearly free electron approximation. Elementary discussion of orthogonalized Plane Wave (OPW) and Pseudo potential methods, Variation of Fermi energy in extrinsic semiconductors, de-Hass-van Alphen effect experiment to investigate Fermi surface.

Unit II Superconductivity: Meissner effect, isotope effect, type I and II superconductors. Cooper pairs. Elementary ideas of BCS theory, Approximate estimate of transition temperature, superconducting energy gap , Measurement of energy gap by infrared absorption and electron tunneling methods, Elementary ideas about Josephoson effect and high Tc superconductors.

Unit III Ionic lattice in presence of infrared field, dielectric constant, L.S.T. relation, LO and TO modes, Ordered phases of matter, translational and orientational order, Quasicrystals, conducting polymers.

Unit IV Lattice defects: Frenkel and Schottky defects, colour centres, number of defects (vacancies) in equilibrium, Dislocations, edge and screw Burgers vector.

Unit V Diamagnetism, Langevin diamagnetic equation, Quantum theory of paramagnetism rare earth ions and iron group ions. Ferromagnetism, Curie temperature, Heisenberg model, Temperature dependence of saturated magnetization.

Text & Reference Books:

1. *S. O. Pillai, Solid State Physics (New Age International (p) Limited, 2013).*
2. *Solid State Physics by C. Kittel (Willey, 2008).*
3. *Solid State Physics by A. J. Dekker (Macmillan).*
4. *Principles of Condensed Matter Physics by Chaikin and lubensky*
5. *Solid State Physics by M A Wahab*
6. *Introduction to Solids by Azaroff*
7. *Elementary Solid State physics by Omar*
8. *Solid State Physics by Aschroft&Mermin*

Paper - II NUCLEAR PHYSICS (PHY-508)

Unit I Deuteron, n-n scattering, n-p scattering, p-p scattering, charge symmetry of nuclear forces.

Unit II Shell Model, Extreme Single particle picture and angular momentum, magnetic moment, quadrupole moment of nuclei, Nuclear Isomerism, Collective model (qualitative discussion)

Unit III Compound Nucleus, Breit Wigner Formula, Direct Interaction, Heavy Ion Reactions, Relativistic Kinematics

Unit IV Fundamental types of Interactions, General Classifications of Elementary Particles, Isospin, Strangeness ,Conservation Laws , Symmetries (C, CP, CPT), SU(3) and quark model

Unit V Alpha, beta and gamma decay

Text & Reference Books:

1. *Nuclear Physics by S.N. Ghoshal, S. Chand & Company Ltd,2004*
2. *Introducing Nuclear Physics by K. S. Krane (Wiley India., 2008) .*
3. *Nuclear Physics - Theory & Experiments by R.R. Roy &B.P.Nigarn (New Age international,2005)*
4. *Nuclear & Particle Physics: An Introduction by B. Martin (Willey,2006)*

5. *Concept of Nuclear Physics by B. L. Cohen (McGraw-Hill,2003)*

Elective Paper3/Special Paper 4 (Specialization-I: Nanoscience & Nanotechnology)

Paper-3: INTRODUCTION TO NANOSCALE SCIENCE AND TECHNOLOGY (PHY-607)

Unit-I: Generic Methodologies for Nanotechnology

Introduction and classification - What is nanotechnology?, Milestone and History of nanotechnology - Classification of nanostructures - Nanoscale architecture; Summary of the electronic properties of atoms and solids - The isolated atom - Bonding between atoms - Giant molecular solids - The free electron model and energy bands - Crystalline solids - Periodicity of crystal lattices - Electronic conduction; Effects of the nanometre length scale - Changes to the system total energy - Changes to the system structure - How nanoscale dimensions affect properties.

Unit-II: Carbon Nanostructures

Introduction; carbon molecules – nature of the carbon bond – new carbon structures; cabon clusters – small carbon clusters discovery of C60 – structure of C60 and its crystal – alkali doped C60 – superconductivity in C60 – large and smaller fullerenes – other buckyballs; carbon nanotubes – fabrication – structure – electrical properties – vibrational properties – mechanical properties; applications of carbon nanotubes – field emission and shielding – computers – fuel cells – chemical sensors – catalysis – mechanical reinforcement.

Unit-III: Inorganic Nanostructures

Metal Nanostructures (Au, Ag, Cu, Al)-Surface Plasmon Resonance, Properties and Application of metal Nanostructures. Overview of relevant semiconductor physics - Quantum confinement in semiconductor nanostructures - The electronic density of states - Fabrication techniques - Physical processes in semiconductor nanostructures (e.g, ZnO etc) - The characterization of semiconductor nanostructures - Applications of semiconductor nanostructures.

Unit-IV: Nanostructured Molecular Materials

Introduction; Building blocks - Principles of self-assembly - Self-assembly methods to prepare and pattern nanoparticles - Templated nanostructures - Liquid crystal mesophases - Macromolecules at interfaces - The principles of interface science - The analysis of wet interfaces - Modifying interfaces - Making thin organic films - Surface effects on phase separation - Nanopatterning surfaces by self-assembly - Practical nanoscale devices exploiting macromolecules at interfaces .

Unit-V: Evolving Interfaces of Nano

Nanobiology - Introduction - Bio-inspired nanomaterials - Interaction Between Biomolecules and Nanoparticle Surfaces - Different Types of Inorganic Materials Used for the Synthesis of Hybrid Nano-bio Assemblies - Applications of Nano in Biology - Nanoprobes for Analytical Applications - Current Status of Nanobiotechnology - Future Perspectives of Nanobiology; Nanosensors - Introduction - What is a Sensor? - Nanosensors - Order from Chaos - Characterization - Perception - Nanosensors Based on Quantum Size Effects - Electrochemical Sensors - Sensors Based on Physical Properties - Nanobiosensors - Smart Dust; Nanomedicines - Introduction - Approach to Developing Nanomedicines - Various Kinds of Nanosystems in Use - Protocols for Nanodrug Administration - Nanotechnology in Diagnostic Applications - Materials for Use in Diagnostic and Therapeutic Applications - Future Directions.

Text & Reference Books:

1. *Nanoscale Science and Technology, Robert W. Kelsall, Ian W. Hamley and Mark Geoghegan, John Wiley & Sons, Ltd., UK, 2005.*
2. *Introduction to Nanotechnology, Charles P. Poole Jr and Frank J. Owens, Wiley Interscience, 2003.*
3. *Bio-Inspired Nanomaterials and Nanotechnology, Edited by Yong Zhou, Nova Publishers.*
4. *Nano:The Essentials: Understanding Nanoscience and Nanotecnology, T.Pradeep, Tata McGraw-Hill Publishing Company Limited, New Delhi, 2008.*

Paper-4: SYNTHESIS AND CHARACTERIZATION OF NANOMATERIALS (PHY-608)

Unit-I: Physical and Chemical Methods

Ball Milling – Electrodeposition - Spray Pyrolysis - Flame Pyrolysis - Inert Gas Condensation Technique (IGCT) – Thermal evaporation – Pulse Laser Ablation in Liquid Media (Metal nanoparticles-Au/Ag/Cu/Al)-Pulsed Laser Deposition (PLD) – DC/RF Magnetron Sputtering - Molecular Beam Epitaxy (MBE), Sol-Gel Process — Self assembly – Metal Nanocrystals by Reduction - Solvothermal Synthesis - Photochemical Synthesis - Sonochemical Routes – Reverse Micelles and Micro emulsions - Combustion Method – Template Process - Chemical Vapor Deposition (CVD) – Metal Oxide Chemical Vapor Deposition (MOCVD)

Unit -II: Lithographic Methods

Introduction – Lithography – Photolithography - Phase-shifting photolithography - Electron beam lithography - X-ray lithography - Focused ion beam (FIB) lithography - Neutral atomic beam lithography - Nanomanipulation and Nanolithography - Soft Lithography - Assembly of Nanoparticles and Nanowires Other Methods for Microfabrication.

Unit -III: Biological Synthesis and Nanocomposites

Introduction - Natural Nanocomposite Materials - Biologically Synthesized Nanoparticles, Nanostructures and Synthetic Nanocomposites - Protein-Based Nanostructure Formation - DNA-Templated Nanostructure Formation - Protein Assembly - Biologically Inspired Nanocomposites - Lyotropic Liquid-Crystal Templating - Liquid-Crystal Templating of Thin Films - Block-Copolymer Templating - Colloidal Templating. Ceramic/Metal Nanocomposites - Metal Matrix Nanocomposites - Nanocomposites for Hard Coatings – Polymer based nanocomposites – nanoscale fillers – processing of polymer nanocomposites – Properties of polymer nanocomposites.

Unit -IV: Characterization Methods- I

X-ray diffraction (XRD) - Debye-Scherer formula – dislocation density – micro strain – Synchrotron Radiation – Principle and Applications –Raman Spectroscopy and its Applications – Dynamic Light Scattering (DLS). Electron microscopes: scanning electron microscope (SEM) – transmission electron microscope (TEM); atomic force microscope (AFM) – scanning tunneling microscope (STM) - XPS – Working Principle, Instrumentation and Applications.

Unit -V: Characterization Methods - II

Impedance Analysis - Micro hardness - nanoindentation – vibrating sample magnetometer – Nuclear Magnetic Resonance (NMR). Differential scanning calorimeter (DSC) – Thermogravimetric/Diffferential Thermal Analyzer (TG/DTA) – UV – Visible Spectrophotometer - FTIR – Principle and Applications – Photoluminescence (PL) Spectroscopy.

Text & Reference Books:

1. *Recent Advances in the Liquid-phase syntheses if inorganic nanoparticles, Brain L.Cushing, Vladimir L.Kolesnichenko, Charles J. O'Connor, Chem Rev. 104 (2004) 3893-3946.*
2. *Nanocrystals: Synthesis, Properties and Applications, C. N. R. Rao, P. J. Thomas and G. U. Kulkarni, Springer (2007).*
3. *Nanotechnology - Enabled Sensors, KouroshKalantar-zadeh and Benjamin Fry, Springer (2008).*
4. *Nanostructures & Nanomaterials: Synthesis, Properties & Applications, Guozhong Gao, Imperial College Press (2004).*
5. *Nanochemistry: A Chemical Approach to Nanomaterials – Royal Society of Chemistry, Cambridge, UK (2005).*
6. *Nanocomposite science and technology, PulickelM.Ajayan, Linda S.Schadler, Paul V.Braun, Wiley-VCH Verlag, Weiheim (2003).*
7. *Encyclopedia of Materials Characterization, C. Richard Brundle, Charles A. Evans Jr., Shaun Wilson, Butterworth-Heinemann Publishers (1992).*
8. *Handbook of Microscopy for Nanotechnology, Ed. By Nan Yao and Zhong Lin Wang, Kluwer Academic Press (2005).*
9. *Nanochemistry, G. B. Sergeev, Elsevier (2006).*
10. *Nanotechnology: Basic Science and Emerging Technologies – Mick Wilson, KamaliKannangara, Geoff Smith, Michelle Simmons, Burkhard Raguse, Overseas Press (2005).*

Handbook of Analytical Techniques, Edited By Helmut Günzler and Alex Williams, Wiley VCH, 2002.

Elective Paper 3/Special Paper 4: Specialization-II: Laser and Spectroscopy
Paper – 3: LASER SPECTROSCOPY(PHY-609)

Unit-I: Light Sources (Arc, Spark, Discharge, Beam Foil etc.), Synchrotron, Laser, Thermal and Direct Photo Detectors, Optical Multichannel Analyzer, Charged Coupled Devices (CCD), Intensified Charged Coupled Devices (ICCD).

Unit-II: Fixed-frequency and Tunable lasers, YAG, Argon Ion, Excimer, Dye, Semiconductor Lasers.

Unit-III: Laser Photoacoustic Spectroscopy, Laser Induced Fluorescence (LIF), Laser Induced Breakdown Spectroscopy (LIBS), Laser Optogalvanic Spectroscopy.

Unit-IV: LaserRaman Spectroscopy (CARS, SRS, SERS), Time Resolved Spectroscopy.

Unit-V: Fourier Transform Spectroscopy, Laser Isotope Separation, Medical Applications of Laser.

Text & Reference Books:

1. *Laser Spectroscopy. Vol 1: Basic Principles, 5/e by W. Demtröder (Springer Nature).*
2. *Laser Spectroscopy. Vol 2: Experimental Techniques, 5/e by W. Demtröder (Springer Nature).*

3. *Introduction to Laser Spectroscopy, 5/e by Halina Abramczyk (Elsevier B.V.)*
4. *Laser Spectroscopy edited by Steven Chu, VladanVuletic, Andrew J. Kerman & Cheng Chin (World Scientific, USA)*
5. *Atom, Laser and Spectroscopy, 2/e by S. N. Thakur and D. K. Rai (PHI Learning Pvt. India)*
6. *Laser-Induced Breakdown Spectroscopy 1/e , edited by Jagdish P. Singh and Surya N. Thakur (Elsevier Science, USA)*
7. *Laser-Induced Breakdown Spectroscopy edited by Sergio Musazzi and Umberto Perini (Springer, UK)*
8. *Handbook of Laser-Induced Breakdown Spectroscopy, 1/e by L.J. Radziemski and David Cremers (Wiley, USA).*

Paper – IV: ELECTRONIC SPECTRA OF DIATOMIC MOLECULE(PHY-610)

Unit-I: Review of electronic spectra of diatomic molecules, Deslander's table, Franck Condon Principle.
Unit-II: Thermal Distribution of quantum state's, Intensity of molecular band in electronic spectra. Effect of nuclear spin on the intensities of fine structure of electronic bands.
Unit-III: Classification of Molecular States, Multiplet Structure, Coupling and Uncoupling phenomena, Selection Rules for Electronic Transitions.
Unit-IV: Building up Principles. Electronic Configuration in diatomic molecule, Molecular Orbital Theory.
Unit-V: Basic concept of continuous and diffused spectra, Determination of heats of dissociation.
Text & Reference Books:

1. *Molecular Spectra and Molecular Structure. Vol 1: Infrared and Raman Spectra, by Herzberg (Springer).*
2. *Molecular Spectra and Molecular Structure. Vol 2: Spectra of Diatomic Molecules by Herzberg (Springer).*
3. *Atomic and Molecular Spectroscopy: Basic Aspects and Practical Applications by SuneSvanberg (Springer)*
4. *Introduction to Molecular Spectroscopy by Gordon M. Barrow (McGraw-Hill)*
5. *Molecular Physics: Theoretical Principles and Experimental Methods by W. Demtröder (Wiley-VCH Verlag).*
6. *Molecular Spectroscopy: Modern Research by K. N. Rao(Academic Press)*
7. *Molecular Spectra by Banwell (Mc Graw Hill).*
8. *Molecular Spectra by J. D. Graybeal (Mc Graw Hill).*

Elective Paper 3/Special Paper 4 Specialization-III: ELECTRONICS

PAPER – III: ANALOG AND DIGITAL ELECTRONICS(PHY-611)
Unit I: Wide band amplifier: Review of BJT at high frequencies. Hybrid pi- equivalent model, Junctioncapacitance, Base spreading resistance, Laplace Transform. RC Amplifier (CE BJT case only), transient response using Laplace Transforms. Effect of an emitter bypass capacitor on low frequency response. High and low frequency compensations.
Unit II: Operational Amplifier: Ideal op-amp. Emitter coupled differential amplifier. CMRR, Effect of constant current source IC op-amp (emitter follower, level translation and out put device). Off – set error voltage and current and there balancing circuits. Temperature drifts, measurement of op-amp parameters.
Unit III: Linear Analog System: Basic op-amp Applications: Inverter, Scale changer, phase shifter, adder, voltage to current converter, current to voltage converter, d.c. voltage follower, differential dc and bridge amplifier, a.c voltage follower, analog integration and differentiation, analog compensation, solution of simultaneous and differential equations upto second order, amplitude and time scaling. Active filter, Butterworth filter, active resonant band pass filter.
Unit IV: Non-linear Analog System: Comparators, sample and hold circuits, AC/DC converters and detectors, log and antilog amplifiers, log multiplier, wave form generator, regenerative comparator.
Unit V: Digital Electronics (TTL Based): Review upto combination logic, Flip Flop: DSR, JK, Master slave, Registers and counters: Shift Register, ripple counter, up down ashynchronous and synchronous counters, ring counter and sequence generators.

PAPER – IV: MICROWAVES(PHY-612)
Unit I: Cylindrical W/G, two conductor system and TEM mode, discontinuity reflection coefficient and SWR, Scattering coefficients of multiple junction, directional coupler, hybrid T, cylindrical cavity resonator ; S.O. of a

cavity resonator, wave meter, attenuator, slotted line, magnetic properties of Ferrites, Faraday rotation, Gyrator and Isolator, Microwave Integrated circuits.

Unit II: Vacuum Tube Microwave Generators: Velocity modulation and density modulation, small signal theory of bunching, two cavity klystron amplifier and multiplier, two cavity klystron Oscillator, Reflex klystron: Theory of bunching, optimum power, effect of repeller voltage, electronic admittance, efficiency, electronic tuning.

Unit III: Magnetron: Travelling wave magnetron, modes of oscillations, output power.

Unit IV: Travelling wave tube: Description, dynamic of electron beam, coupling of beam and slow wave structure, waves in periodic structure, TWT amplifier and BWO, Generation of mm waves.

Unit V: Microwave Measurements: Power, frequency, VSWR, Impedance, dielectric permittivity, Network Analyzer and scattering coefficients.

Practical III, According to Specialization (PHY-703, PHY-704, PHY-705)

PHY-703: Nanoscience & Nanotechnology Lab (Image Analysis/ Experimental)

1. Verification of Lambert Beer's law and determination of concentration of unknown solution by UV-Vis spectrophotometer.
2. Preparation of colloidal Silver (Ag) nanoparticles with trisodium citrate and their characterization by UV-Vis spectroscopy.
3. To study Hydrogen bonding by FT-IR spectroscopy
4. Preparation of metal oxide nanoparticles by microemulsion technique
5. Characterization of prepared metal oxide nanoparticles by XRD and determination of their size by Scherrer's Equation.
6. To determine the Band-Gap of given Semiconductor using Four Probe Method from Liquid Nitrogen Temp to Room Temperature
7. Synthesis of at least two different sizes of Nickel Oxide Nano Particles Using Sol-Gel Method
8. Synthesis of at least two different sizes of Copper Oxide Nano Particles Using Sol-Gel Method
9. Synthesis of at least two different sizes of Zinc Oxide Nano Particles Using Sol-Gel Method
10. Preparation of quantum dot (ZnS) nanoparticles and estimation of band gap from band edge
11. Synthesize copper oxide nanoparticles by sol-gel method and determine the average size of nanoparticles using Zeta sizer.
12. Fabricate silver nanoparticles embedded in silica glass by ion exchange method and study surface plasmon resonance using UV-visible spectroscopy.
13. Fabricate copper nanoparticles embedded in silica glass by ion exchange method and determine the size of nanoparticles using optical absorption spectroscopy.
14. Synthesize silver nanocrystals in solution by citrate reduction method and study the effect of capping using optical absorption spectroscopy.
15. Study the growth kinetics of silver nanoparticles embedded in ion exchanged glass at different temperatures using optical absorption spectroscopy.
16. Drug administration methods
17. Determination of the particle size of the given materials using He-Ne LASER.
18. XRD analysis of the given XRD spectra.

PHY-704: Laser & Spectroscopy Lab (Spectra Analysis), Laser & Spectroscopy Lab (Experimental).

PHY-705:

1. Operational Amplifier,
2. Unijunction Transistor
3.Logicom,
4. Constant Voltage Power Supply
5. Transistor Biasing

Paper 5: Skill Development, Origin (PHY-803)

Unit I: Mathematical calculation: Basic understanding, Addition Subtraction, Multiplication Division.
Unit I: Single x single y data Graph plotting, Single x multiple y date graph plotting, Double x vs y data graph plotting

Unit III: Labelling of x and y exes, labelling of data point in graph.
Unit IV: Graph plotting for given equation such as linear, polynomial, quadratic, Parabola, Circle or any given function.
Unit V: Curve fitting and analysis of linear, polynomial, exponential or any given function.

Paper 6: University Elective, Electric and Magnetic Properties (PHY-903)

Unit 1: Electrostatics in Free Space: Coulomb Law, Electric Field. Simple case of charge distributions. Gauss Flux Law (Integral and Differential forms). Electric Dipole in Electrostatic Field. Irrotational Nature of Electric Potential.
Unit II Polarization, Polarization Charges. Displacement Vector D. Gauss Flux Law (Integral and Differential forms), Simple Problems (Parallel Plate Condenser, Uniformly charged spherical surface and volume).
Unit III Ampere's Law, Biot-Savart's Law, Law of force in Magnetic Field on Currents and charged particles. Magnetic Filed due to a straight infinite wire. Magnetic Field due to circular loop..
Unit IV Equation of Continuity, Maxwell Equations
Uni V: Superconductivity, Meissner effect, Type I and Type II superconductors.

Semester 4

Semester IV

Sl. No.	**Paper**	**Code**	**Type**	**Title of the paper**	**Credit**	**Maximum Marks Exam.**	**Continuous evaluation/Internal assessment**	**Total Marks**
1.	Paper-I	PHY-511	Core-10	EXPERIMENTAL TECHNIQUES & CONTROL SYSTEMS	03	45	30	75
2.	Paper-II	PHY-512	Core-11	ATOMIC & MOLECULAR PHYSICS	03	45	30	75
2.	Paper-III	PHY-613/615/617	*(Elective-I: Nanoscience and Nanotechnology Elective-II: Laser and Spectroscopy Elective III-: Electronics	*MICRO AND NANOFABRICATION/ ADVANCED ATOMIC SPECTROSCOPY/ MICROPROCESSOR/	03	45	30	75
3.	Paper-IV	PHY-614/616/618	*(Specialization-I: Nanoscience and Nanotechnology Specialization-II: Laser and Spectroscopy Specialization-III: Electronics	*APPLICATIONS OF NANOTECHNOLOGY/ ADVANCED ATOMIC SPECTROSCOPY/ X-RAY PHYSICS AND INSTRUMENTATION/ IR & RAMAN SPECTRA OF POLYATOMIC MOLECULES/ ELECTRONIC SPECTRA OF	03	45	30	75

				DIATOMIC MOLECULE				
4	Practical-IV	PHY-605	Project	Thesis /Dissertation	03	45	30	75
5.	Paper-V	PHY-804	SD-1	Device Designing	02	30	20	50
6.	Paper-VI	PHY-909	UE-1	MATLAB PROGRAMMING FOR NUMERICAL METHODS	03	45	30	75
Total					20			500

***In Semester IV, the choice of 4th paper will be based on departmental elective paper. The details are given below**

In Sem. IV,
Ifstudent's elected 3rd paperof "MICRO AND NANOFABRICATION " then the corresponding 4th paper will be "APPLICATIONS OF NANOTECHNOLOGY". **If elected 3rd paper** : "ADVANCED ATOMIC SPECTROSCOPY" then the corresponding 4th paper will be "IR & RAMAN SPECTRA OF POLYATOMIC MOLECULES"**IF elected 3rd paper** : "MICROPROCESSOR" then the corresponding 4th paper will be "ELECTRONICS: SEMICONDUCTOR DEVICES"

Paper-I: EXPERIMENTAL TECHNIQUES & CONTROL SYSTEMS (PHY-511)

Unit-I: Data Interpretation and Analysis: precision and accuracy, error analysis, propagation of errors, least squares fitting, linear and non linear curve fitting, chi-square test.
Unit-II: Optoelectronic Devices and Detectors: Solar cells, Photo-detector, Transducers (Temperature, Pressure, Vacuum pumps and Gauges).
Unit-III: Measurement and Control systems: Signal conditioning and recovery impedance matching. Ideal operational amplifier, characteristics and applications; Inverting and non inverting amplifier, integrator, differentiator, adder and comparator.
Unit-IV: Analogue v/s digital data:Statement of sampling theorem, A/D converters (Flash converters, single slope, double slope and successive approximation converter), D/A converter(R-2R ladder type and weighted resistor type converter), Digit filter (tapped delay line filter).
Unit-V: Fourier Transforms and lock-in detector, Box car averaging. Microprocessor and microcontroller basics, Instruction set related MOV, MVI and I/O commands. Addressing I/O devices (Memory mapped & I/O mapped I/O).

Text & Reference Books:

1. *Introduction to Error Analysis: The Study of Uncertainties in Physical Measurements by John R. Taylor (Publisher University Science Books)*
2. Optoelectronic Devices and Systems by S. C. Gupta (Prentice Hall India Learning Private Limited).
3. *Hand Book of Electronics, 38/e by S. L. Gupta & V. Kumar (Pragati Prakashan).*
4. *Electronic Device & Circuits, 3/e by J. Milliman & C.C. Halkias (McGraw-Hill).*
5. *Modern Digital Electronics 4/e by R.P. Jain (Tata McGraw - Hill Education).*
6. *Microprocessor Architecture Programming & Applications with the 8085, 6/e by R.S. Gaonkar, (Penram Intl. Publishing indiaPvt. Ltd.).*
7. *Microprocessor 8085 and Its Interfacing, 2/e by S. Mathur (PHI Learning).*
8. *Electronic Device & Circuits by A. Mottershead (PHI Learning).*
9. *Electronic Fundamentals and Applications, 5/e by J.D. Ryder (PHI Learning).*
10. *Digital Integrated Electronics by H. Taub & D. Schilling (McGraw-Hill).*
11. *Digital Principles and Applications by A.P. Malvino& D.P. Leach (McGraw-Hill).*
12. *Digital Logic and Computer Design by M. Morris Mano (PHI Learning).*
13. *Microelectronics by J. Millman and A. Grabel (McGraw-Hill).*

Paper II ATOMIC & MOLECULAR SPECTROSCOPY (PHY-512)

Unit I Quantum states of an electron in an atom, Spectrum of Hydrogen and Helium atom, fine structure Spectra of Alkali atoms; energy level diagrams, Sharp, Principal, Diffuse and fundamental series.

Unit II Width of spectral lines, X-ray spectroscopy, Spectroscopic terms; LS & JJ couplings, Hyperfine structure

Unit III Zeeman, Paschen Back & Stark effect, Electron spin resonance, Nuclear magnetic resonance, chemical shift

Unit IV Spectra of Diatomic Molecules Rotational Spectra (rigid rotator and non rigid rotator model) Vibrational Spectra (harmonic and enharmonic model) Molecular Symmetric Top, Vibrating rotator Isotopic shift

Unit V Raman Spectra (Quantum mechanical and classical approach) Electronic Spectra-vibrational structure of band system, fine structure of the band systems. Intensity distribution in band systems: Frank Condon principle.

Text & Reference Books:

7. *Atomic and Molecular Spectra by Raj Kumar (Kedar Nath Ram Nath).*
8. *Molecular Structure and Spectroscopy by G. Aruldhas (PHI Learning).*
9. *Introduction to Atomic Spectra by H. E. White (McGraw-Hill).*
10. *Molecular Spectra and Molecular Structure, Vol I: Spectra of Diatomic Molecules by G. Herzberg (Krieger Publishing Company).*
11. *Fundamental of Molecular Spectroscopy,4/e by C. N. Banwell (McGraw-Hill)*
12. *Atoms and Molecules: An Introduction for Students of Physical Chemistry by M. Karplus and R.N. Porter (Benjamin–Cummings Publishing Company).*

Elective Paper 3 & Special Paper 4: Paper 3 & 4, Specialization-I: Nanoscience & Nanotechnology

Paper: III: MICRO AND NANOFABRICATION (PHY-613)

Unit-I: Basic Microfabrication Techniques

Basic Microfabrication Techniques: Lithography - Thin Film Deposition and Doping : Oxidation – Doping – Chemical Vapor Deposition and Epitaxy – Physical Vapor Deposition – Electroplating - Etching and Substrate Removal : Wet Etching – Dry Etching – Substrate Bonding : Si Direct Bonding – Anodic Bonding – Bonding with Intermediate Layers.

Unit-II: MEMS and NEMS

MEMS Fabrication Techniques: Bulk Micromachining - Surface Micromachining - High-Aspect-Ratio Micromachining - Nanofabrication Techniques: e-Beam and Nano-Imprint Fabrication - Epitaxy and Strain Engineering - Scanned Probe Techniques - Self-Assembly and Template Manufacturing.

Unit-III: Material Aspects and Applications of MEMS/NEMS

Silicon - Germanium-Based Materials – Metals - Harsh Environment Semiconductors - GaAs, InP, and Related III-V Materials - Ferroelectric Materials - Polymer Materials - Future Trends - MEMS Devices and Applications - NEMS Devices and Applications - Current Challenges and Future Trends.

Unit-IV: Clean Room

Clean room standards – Clean room sub systems – Environment, Safety and Health Aspects.

Unit-V: Process Integration

Junction and Oxide Isolation – LOCOS Methods – Trench Isolation – Silicon on Insulator Isolation Techniques – Semi insulating Substrates – Schottky Contacts – Implanted Ohmic Contacts – Alloyed Contacts – Multilevel Metallization – Planarization and Advanced Interconnect.

Text & Reference Books:

1. *Springer Handbook of Nanotechnology, Bharat Bhushan, Springer, 2004.*
2. *Introduction to Microfabrication, Sami Franssila, John Wiley & Sons Ltd, 2004.*
3. *The Science and Engineering of Microelectronic Fabrication, Stephen A. Campbell, Oxford University Press 2001.*
4. *Microfabrication and Nanofabrication, Mark J. Jackson, CRC Taylor &Fancis, 2006.*
5. *Nano and Microelectromechanical Systems : Fundamentals of Nano and Microengineering, Sergey Edward Lyshevski, CRC Press, 2001.*

Paper: IV: APPLICATIONS OF NANOTECHNOLOGY (PHY-614)

Unit-I: Sensors

Sensors - Nanotechnology Enabled Sensors - Sensor Characteristics and Terminology - Static and Dynamic Characteristics; Inorganic Nanotechnology Enabled Sensors - Gas Sensing with Nanostructured Thin Films - Phonons in Low Dimensional Structures - Nanotechnology Enabled Mechanical Sensors - Nanotechnology Enabled Optical Sensors - Magnetically Engineered Spintronic Sensors; Organic Nanotechnology Enabled Sensors - Surface Interactions - Surface Materials and Surface Modification - Proteins in Nanotechnology Enabled Sensors - Nano-sensors based on Nucleotides and DNA.

Unit-II: Energy Devices

Solar Cells - Band Diagram and Operational Principle of Nanocrystalline Solar Cells - The Importance of the Nanostructure - Quantum Dot Sensitizer; Electrochemistry and Nanoscale Materials - Electrochemistry and Size Effects - Challenges of Charge Transfer - Nanomaterials and Nanostructured Films as Electro active Electrodes - Nanomaterials as Electrolytes - Nanoscale Electronic and Ionic Transport – Energy Conversion and Storage in Electrochemistry - Overview of the Principles of Operation of Energy Conversion and Storage Devices - Lithium Ion Batteries - Fuel Cells - Photoelectrochemical Solar Cells - Electrochemical Double-Layer Capacitors - What Relevance Has Nanotechnology for Fuel Cell Systems - Fuel Cell Technology and Nanotechnology.

Unit-III: Potential Defence Applications

Military applications of Nanotechnology - Electronics, photonics, magnetic - Computers, Communication - Software/Artificial Intelligence – Materials -Energy Sources, Energy Storage - Propulsion – Vehicles - Propellants and Explosives – Camouflage -Distributed Sensors - Amour, Protection - Conventional Weapons - Soldier Systems - Implanted Systems, Body Manipulation - Autonomous Systems - Mini-/Micro Robots - Bio-technical Hybrids - Small Satellites and Space Launchers - Nuclear Weapons - Chemical Weapons - Biological Weapons - Chemical/Biological Protection.

Unit-IV: Nanostructured Food and Packaging Materials

Natural Food Nanostructures - Naturally Occurring Food Nanosubstances and Nanostructures - Designing Food Nanostructures - The Status of Natural Nanostructures in Food - Nanomaterials for (Health)food Applications - Nano-sized Food Ingredients and Additives in Relation to Digestion of Food - Nanotechnologies in Food Packaging - Improvement of Mechanical Properties through Nanocomposites - Improvement of Barrier Properties - Improvement of the Performance of Bio-based Polymers - Surface Biocides - Active Packaging Materials - Intelligent Packaging Concepts.

Unit-V: Biomedical Applications and Nanoparticles in Drug Delivery

Magnetic Nanoparticles as Contrast Agents for Medical Diagnosis - Nanoparticles in Medicine - Size-Dependent Effects of Magnetic Particles – Preparation - Methods for Iron Oxide Nanoparticles and *in-vitro* Characterization – *in- vivo* Investigations - Using Nanoparticles in Animals - Magnetic Nanoparticles for Imaging and Therapy in Humans - Toxicity of Nanoparticles - Future Perspectives. Nanoparticulate Drug Delivery to the Reticuloendothelial System and to Associated Disorders – Delivery of Nanoparticles to the Cardiovascular System – Nanocarriers for the Vascular Delivery of Drugs to the Lungs – Nanoparticulate Carriers for Drug Delivery to the Brain – Nanoparticles for Targeting Lymphatics – Polymeric Nanoparticles for Delivery in the Gastro-Intestinal Tract – Nanoparticular Carriers for Ocular Drug Delivery – Nanoparticles and Microparticles as Vaccines Adjuvants.

Text & Reference Books:

1. *Nanotechnology - Enabled Sensors, KouroshKalantar-zadeha and Benjamin Fry, Springer, 2008.*
2. *Nanostructured Materials for Electrochemical Energy Production and Storage, David J. Lockwood, Springer, 2009.*
3. *Nanotechnology in Biology and Medicine: Methods, Devices and Applications, Tuan Vo-Dinh, CRC Press, 2007.*
4. *Military Nanotechnology: Potential Applications and Preventive Arms Control, Jürgen Altmann, Routledge, Taylor and Francis Group, 2006.*
5. *Nanotechnologies in Food, Qasim Chaudry, Laurence Castle and Richard Watkins, RSC Publications, 2010.*
6. *Recent Trends in Fuel Cell Science and Technology, Edited by SuddhasatwaBasu, Springer (2007).*
7. *Nanomedicine, Vijay K. Varadan, Linfeng Chen, Jining Xie, A John Wiley and Sons, Ltd., Publication (2008).*
8. *Biological Nanostructures and Applications of Nanostructures in Biology : Electrical, Mechanical, and Optical Properties, Edited by Michael A. Stroscio and Mitra Dutta, Kluwer Academic Publishers (2004).*
9. *Nanoparticles as Drug carriers, Vladimir P Torchilin, Imperial College Press, USA, 2006*
10. *Nanomedicine, Parag Diwan and Ashish Bharadwaj, pentagon press, India, 2006.*

Elective Paper 3 & Special Paper 4: Paper 3 & 4,Specialization-II: Laser and Spectroscopy

Paper – III: ADVANCED ATOMIC SPECTROSCOPY (PHY-615)

Unit-I: Lamb – shift in hydrogen spectrum.
Unit-II: Complex Spectra and their interpretation, nitrogen, oxygen and manganese as examples, Alternation of multiplicities, Inversion of states.
Unit-III: Breit's Scheme for spectral term derivation, Rydberg atoms and Rydberg states.
Unit-IV: Inductively Coupled Plasma Optical Emission Spectroscopy (ICP-OES), Inductively Coupled Plasma Mass Spectroscopy (ICP-MS), LIBS, Photo electron spectroscopy (PES), Auger Electron Spectroscopy (AES), X-Ray Fluorescence Spectroscopy (XRF).
Unit-V: Limitations of Optical Microscope and Electron Microscope, Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM), Atomic Force Microscopy (AFM), Scanning Tunneling Electron Microscopy (STEM), Fluorescence Microscopy.

Text & Reference Books:

1. *Atomic Spectra and Atomic Structure, 2/e by Gerhard Herzberg (Dover Publication).*
2. *Atomic and Molecular Spectroscopy: Basic Aspects and Practical Applications by SuneSvanberg (Springer).*
3. *Atomic Spectroscopy, 2/e by James W. Robinson (CRC Press).*
4. *Introduction to Atomic Spectra by H. E. White (McGraw-Hill).*
5. *Theoretical Atomic Spectroscopy, 1/e by ZenonasRudzikas (Cambridge University Press)*
6. *Atom, Laser and Spectroscopy, 2/e by S. N. Thakur and D. K. Rai (PHI Learning Pvt. India)*
7. *Laser-Induced Breakdown Spectroscopy 1/e, edited by Jagdish P. Singh and Surya N. Thakur (Elsevier Science, USA).*
8. *Laser-Induced Breakdown Spectroscopy edited by Sergio Musazzi and Umberto Perini (Springer, UK).*
9. *Handbook of Laser-Induced Breakdown Spectroscopy 1/e,by L.J. Radziemski and David Cremers (Wiley, USA).*
10. *Handbook of Microscopy of Nanotechnology edited by Nan Yao and Zhong Lin Wang (Kluwer Academic Publishers, USA).*

Paper – IV: IR & RAMAN SPECTRA OF POLYATOMIC MOLECULES(PHY-616)

Unit-I: Symmetry Elements and Symmetry Operations, Point Groups, Classification of Molecules into PointGroups.
Unit-II: Rotation and Rotational Spectra of Linear Polyatomic Molecules and Symmetric Top Polyatomic Molecules, Energy Levels and Symmetry Properties, Influence of Nuclear Spin and Statistics, Rotational Structure in the Far Infrared, Rotational Structure in the Raman Spectra & Alteration of Intensity.
Unit-III: Vibrational Motion, Motion in Cartesian Coordinates, Mass Weighted Cartesian Coordinates, Normal Coordinates and Normal Modes of Motion; Vibrational Energy, Infra-red and Raman Vibrational Spectra.
Unit-IV: Fermi Resonance, Several Potential Minima and Inversion in Ammonia Molecule, Torsional oscillations, Active and Inactive IR and Raman Fundamentals, Functional Group Analysis.
Unit-V: Interaction of Rotation and Vibration, Rotation Vibration Spectra of Linear Polyatomic Molecule, Energy levels and Symmetry Properties, Coriolis Interaction, IR and Raman Spectra of Linear Polyatomic Molecule.

Text & Reference Books:

1. *Molecular Spectra and Molecular Structure. Vol 3: Spectra of Polyatomic Molecules by Herzberg (Springer).*
2. *Atomic and Molecular Spectroscopy: Basic Aspects and Practical Applications by SuneSvanberg (Springer)*
3. *Introduction to Molecular Spectroscopy by Gordon M. Barrow (McGraw-Hill)*
4. *Molecular Spectroscopy: Modern Research by K. N. Rao(Academic Press)*
5. *Molecular Spectra by Banwell (Mc Graw Hill).*
6. *Molecular Spectra by J. D. Graybeal (Mc Graw Hill).*

Elective Paper 3 & Special Paper 4: Paper 3 & 4,Specialization-III: ELECTRONICS

PAPER – III: MICROPROCESSOR (PHY-617)

Unit I: Microprocessor: Microprocessor 8085, Instruction set, Simple programs,
Unit II: Memory organization and mapping, I/O devices Chip select and interfacing in I/O mapped and memory mapped I/O schemes.
Unit III: Hardware description of 8085.
Unit IVPIA 8255 Handshaking via interrupt and polling, CMOS devices as RAM and ROM. Memory refresh.
Unit V:A to D and D to A converter, IC ADC0809 and DAC08, Pin Out their interfacing with 8085.

PAPER – IV: ELECTRONICS: SEMICONDUCTOR DEVICES (PHY-618)

Unit I: SemiconductorPhysics:Carrierconcentrationinintrinsicandextrinsicsemiconductors,recombinationprocess,currentdensityandcontinuityequations, decayofphoto excitedcarrirs, steadystate injunction, transientand steadystatediffusion.
Unit II : P-njunctiondiode:Junctionanddiffusioncapacitance,diodeequation,breakdowns,temperaturedependenceofvoltage andcurrent.Varactordiode andparametricconversion andamplification,
Unit III: Tunneldiode,V-Icharacteristics,tunneldiodeasanamplifierandasanoscillator.
Unit IV: Gunndiode,modesofoperation,powerandfrequencyperformance.Impact:Staticanddynamiccharacteristic,smallsignalanalysisandnegativeconductance,powerandfrequencyperformance,devicedesignandperformance.
Schottkyeffect and Schottkydiode.
Unit V:BJT:Currentvoltagerelationsinactive,cutoffandsaturationregions,microwavetransistor,cutofffrequency,device geometryandperformance.

Practical IV,Thesis /Dissertation(PHY-706/707/708)

Paper 5, Skill Development (PHY-804)
Device Designing

1. Design of full wave rectifier with filter circuit.
2. Design of regulated power supply.
3. Design of Different GATES.
4. Design of adder and subtractor circuits.
5. Design of Analog to Digital converter
6. Design of Digital to Analog converter.

Paper 6, University Elective (PHY-904)

MATLAB PROGRAMMING FOR NUMERICAL METHODS (PHY-904)
Unit 1: Data files and Data types: Character and string, Arrays and vectors, Column vectors, Row vectors
Basic Mathematics: Arithmetic operations, Operators and special characters, Mathematical and logical operators, solving arithmetic equations
Unit 2: Operation on matrix: Creating rows and columns matrix, Matrix operation, Finding transpose, determinant and inverse, solving matrix
M files: Working with script tools, writing script file, executing script file, The MATLAB editor, Saving M files
Plots: Plotting vector and matrix data, 2D plots, 3D plots
Unit 3: Introduction to MATLAB Programming: Basics of MATLAB programming, Array operations in MATLAB, Loops and execution control, Working with files: Scripts and Functions, Plotting and program output
Unit 4: Numerical Differentiation and Integration:Numerical Differentiation in single variable, Numerical differentiation: Higher derivatives, Differentiation in multiple variables,Newton-Cotes integration formulae,Multi-step application of Trapezoidal rule,MATLAB functions for integration
Unit 5: Ordinary Differential Equations (ODE):Introduction to ODEs; Implicit and explicit Euler's methods, Second-Order Runge-Kutta Methods,MATLAB ode45 algorithm in single variable,Higher order Runge-Kutta methods,Error analysis of Runge-Kutta method

Reference Books:

1. Fausett L.V. (2007) Applied Numerical Analysis Using MATLAB, 2nd Ed., PearsonEducation
2. Chapra S.C. and Canale R.P. (2006) Numerical Methods for Engineers, 5th Ed., McGraw Hill

3. E William Schiesser and W G Graham *A Compendium of Partial Differential Equation Models* (Cambridge University Press) (2009).