Natural Science (Mathematics, Physics and English)

Course Title	**:**	**Topics in Numerical Analysis**			
Course Code	**:**	**MTH-601**	**Course Type**	**:**	**Core 1**
Contact Hours	**:**	**L- 3 T- 0 P- 0**	**Credit**	**:**	**4**
Program/Semester	**:**	**Ph.D. / 1st semester/ 2nd /3rd semester**			
Pre-requisites	**:**	**None**			
Evaluation Scheme	**:**	**Quiz-10%, Mid-Sem- 20%, End-Sem- 40%, Project etc.-30%**			

Course Details:

Module-1: Representation of numbers, basic definition and source of errors, efficient solution of large scale systems of equations using direct methods and iterative methods and their error analysis, pivoting, scaling and condition numbers **(10H)**

Module-2: Root finding methods for nonlinear equations and system of equations, Interpolations; Forward difference, Backward difference and central difference interpolations, Spline; introduction and importance of spline function; polynomial spline; cubic spline, B-spline, Existence of approximate function for continuous function, Discrete & continuous least square approximations **(11H)**

Module-3: Numerical methods and their error analysis for solving boundary value problems and Initial value problems, numerical integrations; methods based on interpolation, method based on undetermined coefficients, Adaptive Quadrature Methods, Multiple Integrals **(10H)**

Module-4: Eigenvalue location, error and stability estimates, Jacobi, Given methods, and householder's methods for symmetric matrices, krylov space, arnoldi methods for general matrix, existence of simple and multiple eigenvalues and eigenvectors**.(11H)**

References:

Text/Reference books:

1. K.E. Atkinson; An introduction to numerical analysis, Wiley, 2nd Edition, 1989
2. S.D. Conte & C. De Boor; Elementary Numerical Analysis-An Algorithm Approach, McGraw Hill, 3rd Edition, 1981.
3. Gene H. Golub and Charles F. Van Loan, Matrix Computations, Johns Hopkins University Press, Baltimore, USA, 3rd Edition, 1996.
4. M. K. Jain, S R K Iyengar, R.K. Jain, Numerical Methods for Scientific and Engineering Computation, 4th Edition, New Age International (P) Ltd. 2004.

Course Title	**:**	**Numerical Solution to PDE**			
Course Code	**:**	**MTH-602**	**Course Type**	**:**	**Core 1**
Contact Hours	**:**	**L- 3 T- 0 P- 0**	**Credit**	**:**	**4**
Program/Semester	**:**	**Ph.D./1st semester/ 2nd semester/3rd Semester**			
Pre-requisites	**:**	**Basic knowledge of Mathematics.**			
Evaluation Scheme	**:**	**Quiz-10%, Mid-Sem- 20%, End-Sem- 40%, Project etc.-30%.**			

Course Details:

Module1: Classification of PDEs, Taylor's Theorem and its application to derivation of Finite Difference approximation to partial derivatives. **(10H)**

Module2: Parabolic equations in one and two dimensions- explicit and implicit schemes, consistency, stability and convergence. **(10H)**

Module3: Elliptic equation in two dimensions- explicit and implicit schemes, consistency, stability and convergence. **(10H)**

Module4: - Hyperbolic equation, explicit and implicit schemes, method of characteristics. Solution of wave equation. Von- Neumann Stability, Finite Fourier series and its application to stability. Conservation laws, Weak Solution & Shocks. **(12H)**

References:

Text/Reference books:

1. Numerical Partial Differential Equation- Finite Difference Methods, J.W. Thomas, Springer Verlag (TAM), 1999
2. Numerical Partial Differential Equation- Conservation Laws and elliptic Equations, J.W. Thomas, Springer Verlag (TAM), 1999.
3. Numerical Solution of Hyperbolic PDE, John Trangenstein, Cambridge University Press, 2009.
4. Finite Difference Schemes and PDE, John C. Strikwerda, 2nd Edition, SIAM, 2004.

Course Title	**:**	**Spectral Methods: Theory and its applications**			
Course Code	**:**	**MTH-603**	**Course Type**	**:**	**Core 1**
Contact Hours	**:**	**L- 3 T- 0 P- 0**	**Credit**	**:**	**4**
Program/Semester	**:**	**Ph.D./ 1st semester/ 2nd semester/3rd semester**			
Pre-requisites	**:**	**None**			
Evaluation Scheme	**:**	**Quiz-10%, Mid-Sem- 20%, End-Sem- 40%, Project etc.-30%.**			

Course Details:

Module-1: Introduction of Spectral methods, advantages and difference from its alternative, Classifications of methods; Galerkin methods, Tau methods and collocation methods, differences and similarities in all these three approach **(7H)**

Module-2: Fourier series; Fourier convergence theorem, Cosine and Sine series expansion, Approximation; Orthogonal polynomials; the general Sturm-Liouville problems, Jacobi polynomials, trigonometric polynomials, Chebyshev polynomials, Legendre polynomials, derivative of function, differentiation matrices **(8H)**

Module-3: Fourier- Galerkin Method and Fourier collocation method, stability for Fourier Galerkin methods, stability for Fourier collocation methods for time dependent problems, Continuous and discrete expansion for smooth functions **(12H)**

Module-4: Polynomial spectral methods; Galerkin & Tau method, pseudospectral methods, pseudospectral method for time dependent linear equation, pseudospectral method non-linear equation, Spectral methods for nonsmooth problems; The Gibbs phenomenon and Filters. **(15H)**

References:

Text/Reference books:

1. J. P. Boyd; Chebyshev and Fourier Spectral Methods (Second edition), Dover Publication, New York-2000 .
2. Hesthaven Jan S., Gottlieb Sigal and Gottlieb David; Spectral Method for Time Dependent Problems, Cambridge University Press-2007
3. Karniadakis George and Sherwin Spencer ; Spectral/hp Element Methods for Computational Fluid Dynamics (Second Edition), Oxford Science Publications-2005
4. C. Canuto, M.Y. Hussani, A. Quarteroni and T.A. Zang; Spectral methods- Fundamentals in single domains, Springer Verlag-2006

Course Title	**:**	**Programming & Computational methods of PDE**			
Course Code	**:**	**MTH-604**	**Course Type**	**:**	**Core 1**
Contact Hours	**:**	**L- 3 T- 0 P- 0**	**Credit**	**:**	**4**
Program/Semester	**:**	**Ph.D./ 1st semester/ 2nd semester/3rd semester**			
Pre-requisites	**:**	**NS 602.**			
Evaluation Scheme	**:**	**Quiz-10%, Mid-Sem- 20%, End-Sem- 40%, Project etc.-30%**			

Course Details:

Module1: Introduction to C programming, C's character set, Form/layout of a C program, Pre-processor directives. : Control flow (Statement and blocks, If-else, Else-If, Switch etc.) **(10H)**

Module2: Functions and Program Structure (Basics of Function, Functions returning non integer, External variables, Scope rules, header files, static variable, register variable, block structure), Pointers and Arrays (Accessing a Variable Through Pointer, Pointer – Memory Allocation, Pointer – Declaration & Initialization, Pointer – Dereferencing, Pointers & Arrays, Character Arrays using Pointers, Array of Character Pointers), **(12H)**

Module3: Functions & Pointers (Invoking Functions,Passing Arguments to Functions, Call by Value & Reference, Array as Function Argument, Rules for Array Argument Passing, Multi-dimensional Array Argument Passing, Structure as Function Argument), Dynamic Memory Allocations (malloc, calloc, realloc, free, malloc Vs calloc, Heap Memory), Debugging Techniques. **(12H)**

Module4: - Parabolic partial differential equation, hyperbolic partial differential equation and Elliptic partial differential equation. **(8H)**

References:

1. The C Programming Language – B.W. Kernigham, D.M. Ritchie, IInd Edition, PHI, 1990.
2. A Book on C --- A.L. Kelly, Ira Pohl, 4th Edition, Pearson. 2008.
3. Numerical Partial Differential Equation- J.W. Thomas, Springer Verlag (TAM), 1999.
4. Numerical methods for Conservation Laws, R.J. Leveque, 2nd Edition, Birkhauser. 2008.

Course Title	**:**	**Analysis**			
Course Code	**:**	**MTH-611**	**Course Type**	**:**	**Core 1**
Contact Hours	**:**	**L- 3 T- 0 P- 0**	**Credit**	**:**	**4**
Program/Semester	**:**	**Ph.D./ 1st semester/ 2nd semester/3rd semester**			
Pre-requisites	**:**	**None**			
Evaluation Scheme	**:**	**Quiz-10%, Mid-Sem- 20%, End-Sem- 40%, Project etc.-30%.**			

Course Details:

Module1: Metric space, interior points, open set, limit points, closed set, dense, continuous and uniform continuous functions, sequence, Cauchy sequence, complete metric space, Cantors intersection theorems, Baire's theorem, Compact metric space, sequentiallycompact, Heine Borel theorem, Finite Intersection property, Balzano Weierestrass property, bounded and totally bounded, separable, equicontinuous, Ascoli theorem, Connected space, maximal connected, locally connected. **(10H)**

Module2: Normed linear spaces, Banach space, bounded linear functionals and bounded linear operators, dual spaces. **(10H)**

Module3: Banach contraction mapping theorem, Hahn-Banach theorem, uniform boundedness principle, open mapping and closed graph theorems, weak convergence. **(10H)**

Module4: - Hilbert spaces, orthonormal sets, Riesz representation theorem, bounded linear operators on Hilbert spaces. **(10H)**

References:

1. B.V. Limaye, Functional Analysis.
2. E. Kresyzig, Introductory Functional analysis with applications.
3. G.F Simmons, Introduction to topology and modern analysis.
4. W. Rudin, Real And Complex Analysis.

Course Title	**:**	**Introduction to Mathematical Statistics and Probability.**			
Course Code	**:**	**MTH-621**	**Course Type**	**:**	**Core 1**
Contact Hours	**:**	**L- 3 T- 0 P- 0**	**Credit**	**:**	**4**
Program/Semester	**:**	**Ph.D./1st semester/ 2nd semester/3rd Semester**			
Pre-requisites	**:**	**Basic knowledge of Mathematics.**			
Evaluation Scheme	**:**	**Quiz-10%, Mid-Sem- 20%, End-Sem- 40%, Project etc.-30%.**			

Course Details:

Module1: Mathematical Statistics and Probability: Frequency Distribution, Measure of Central Tendency, Measure of Dispersion, Skewness, and Kurtosis, Correlation, Regression, Basic Set Operations, Construction and requirement of Algebra and Sigma algebra, Concept of Measurable Space & Measurable Function, Probability Measure, Random Variable, Distribution Function, Dependent & Independent Event, Mathematical Expectation, Conditional Probability Measure, Bayesian Probability, Function of Several Variables, Moments of Random Variables, Moments Generating Function, Characteristic Function. **(20 H)**

Module2: Estimation and Inference: Point Estimation, Unbaised estimator, Consistent estimator, Sufficient estimator, Efficient estimator. Method of Estimation: Method of moments, Maximum Likelihood Estimation. Best Linear Unbiased estimators, Confidence Interval. Testing of Hypothesis: Acceptance Region, Critical Region, Test function, Type-I and Type-II Errors, Level of Significance, Power of the Test, Uniformly Most Powerful Test , Neyman-Person's Lemma. **(12H)**

Module3 Large Sample and Exact Sampling Tests:. Large Sampling Tests: z-test, Test of Significance for single mean, Test of Significance for Differences of Means, Test of Significance for Differences of Standard Deviation. Chi-Square Distribution, Chi-Square test for goodness of fit, Student's t−Distribution, t−test for single mean, t−test for difference of means, Paired t−test for difference of means, F-distribution, F−test for equality of population variance. **(10H)**

References:

1. An Introduction to Probability and Statistics ---- V.K.Rohatgi, Saleh
2. Probability and Statistics in Engineering ----W.W.Hines, D.C. Montgomery, D.M. Goldman, C.M.Borror.
3. A Course in Probability Theory---- Kai Lai Chung
4. Introduction to Mathematical Statistics ----Hogg, Mckean, Craig

Course Title	**:**	**Optimization Theory and Applications**			
Course Code	**:**	**MTH-631**	**Course Type**	**:**	**Core 1**
Contact Hours	**:**	**L- 3 T- 0 P- 0**	**Credit**	**:**	**4**
Program/Semester	**:**	**Ph.D./1st semester/ 2nd semester/3rd Semester**			
Pre-requisites	**:**	**Basic knowledge of Mathematics.**			
Evaluation Scheme	**:**	**Quiz-10%, Mid-Sem- 20%, End-Sem- 40%, Project etc.-30%.**			

Course Details:

Linear Programming Problem
Introduction, Linear Programming Problem (LPP), Requirements of LPP, Mathematical formulation of LPP, Examples from industrial cases, Graphical method to Solve linear programming problems, Applications, Advantages, Limitations, Motivation of the simplex method, Simplex method, Penalty cost method or Big M-method, Two phase method, Importance of duality concepts, Formulation of dual problem, Economic interpretation of duality, Dual simplex method. **(12H)**

Integer Programming and Dynamic Programming
Introduction, Difficulty of Integer Programs, Formulation of various industrial problems as integer and mixed integer programming problems, Branch and bound algorithm, Cutting plane method, Multistage decision processes, Concept of Bellman's principle of optimality and recursive relationship of dynamic programming for various optimization problems. **(9H)**

Goal Programming and Sequencing Problems
Introduction, Goal programming formulation and method, Solution of sequencing problem, Processing n Jobs through 2 Machines, Processing n Jobs through 3 Machines, Processing 2 Jobs through m machines. **(8H)**

Nonlinear Programming: Introduction
Introduction, Motivation, Types of nonlinear programming problems, Differentiable convex function, Karush-Kuhn-Tucker (KKT) Conditions for constrained optimization, Convex programming problem, Separable programming problem and examples. **(8H)**

Game Theory and Decisions Making
Introduction, Concepts of Game problem, Game theory to determine strategic behaviour, Elements of decision theory and decision trees, Two-person zero-sum games, Games without saddle points, Dominance property, Use of linear programming to games. **(5H)**

References:

1. Introduction to Operations Research - F.S. Hiller and G.J. Lieberman, McGraw Hill, 8th Edition, 2005, ISBN: 978-0-07-060092-8.
2. Operations Research- P. Sankara Iyer, McGraw Hill Education, 1st Edition, 2008, ISBN: 9780070669024.
3. Operations Research: An Introduction- H.A. Taha, Pearson Prentice Hall, 8th Edition, 2007, ISBN 0-13-188923·0.
4. Engineering Optimization Theory and Practice- S.S. RAO, John Wiley & Sons, Inc., 4th Edition, 2009, ISBN: 978-0-470-18352-6.

Course Title	**:**	**Magnetic & Electronic Properties of Solids**			
Course Code	**:**	**PHY-608**	**Course Type**	**:**	**Core 1**
Contact Hours	**:**	**L- 3 T- 0 P- 0**	**Credit**	**:**	**4**
Program/Semester	**:**	**Ph.D./1st semester/ 2nd semester/3rd Semester**			
Pre-requisites	**:**	**NONE**			
Evaluation Scheme	**:**	**Quiz-10%, Mid-Sem- 20%, End-Sem- 40%, Project etc.-30%.**			

Course Details:

Module1: Magnetism: Dia- , Para-magnetism and their Quantum Theory, Langevin Diamagnetism, Hund's rules, Crystal field splitting, Van-Vleck and Pauli paramagnetism, Ferro- , Anti- and Ferri-magnetism, Curie-Weiss law and Exchange interactions, Saturation magnetization. **(12H)**

Module2: Magnons, Neutron Magnetic Scattering, Ferromagnetic domains, Anisotropy energy, Magnetic Force Microscopy. Magnetic Resonance: Para-, Ferro- and Anti-ferromagnetic, spin wave, resonance absorption, Hyperfine splitting. **(10H)**

Module3: Quantum Tunneling effect, Magnetoresistance Materials (CMR, GMR, Spin Valve and TMR etc). Superconductivity: phenomenology, type-I/II, GL theory and some ideas of microscopic origin. **(9H)**

Module4: Dielectrics and ferroelectrics, Polarization, Dielectric constant and Polarizability, Ferroelectric crystals Landau theory of the phase transition, Plasmons, Polarons, Optical processes and excitons in solids. **(10H)**

References:

1. C. Kittel, Introduction to solid state physics, 8th Edition, ISBN : 978-0-471-41526-8, 704 pages, October 2004, ©2005
2. W. Callister, Materials Science and Engineering: An Introduction, 9th Edition, ISBN : 978-1-118-32457-8, 984 pages, November 2013, ©2014
3. N. Ashcroft and N.D. Mermin, Solid state physics, Cengage Learning, 2011, ISBN: 8131500527, 9788131500521, 826 pages
4. C. N. R. Rao, and B. Raveau, Colossal Magnetoresistance, Charge Ordering and related properties of manganese oxides, World Scientific: Singapore, ISBN:9810232764, 1st Edition 1998.

Course Title	**:**	**Nanomaterials: Design & Characterization**			
Course Code	**:**	**PHY-610**	**Course Type**	**:**	**Core 1**
Contact Hours	**:**	**L- 3 T- 0 P- 0**	**Credit**	**:**	**4**
Program/Semester	**:**	**Ph.D./1st semester/ 2nd semester/3rd Semester**			
Pre-requisites	**:**	**NONE**			
Evaluation Scheme	**:**	**Quiz-10%, Mid-Sem- 20%, End-Sem- 40%, Project etc.-30%.**			

Course Details:

Module1: Materials in nanodimension and their basic properties, Synthesis of Nanomaterials by various methods. **(9H)**

Module2: Inorganic Nanotubes & Nanowires, Metal Nano clusters, Nanostructure Multilayers. Methods of measuring properties of Nanomaterials. **(11H)**

Module3: Preparation of Quantum Nanostructures, Size Effects, Conduction Electrons and Dimensionality, Properties of Nanostructured materials. Effect of Density of States on properties**. (8H)**

Module4: Nature of Carbon Clusters, Discovery of C60, Structure of C60 and its Crystal, Superconductivity in C60, Carbon Nanotubes in single- & multi-walled: Synthesis, Structure, Electrical and Mechanical Properties. Graphene. Quantum -Wells, -Wires and -Dots. **(12H)**

References:

1. Charles P. Poole and F. J. Owens, Introduction to Nanotechnology, Wiley Interscience, ISBN : 978-0-471-07935-4, 400 pages, May 2003, ©2003
2. D. K. Schroder, Semiconductor Material and Device Characterization, ISBN : 978-0-471-73906-7, 800 pages, January2006, ©1990
3. CNR Rao and A Govindaraj, Nanotubes and Nanowires, RSC Publishing (Nanoscience & Nanotechnology Series), ISBN 13: 9781849730587©2005.
4. CNR Rao, A. Muller, A.K. Cheetham, The Chemistry of Nanomaterials: Synthesis, Properties and Applications28 JAN 2005 ISBN: 9783527306862©2004

Course Title	**:**	**Bionanotechnology**			
Course Code	**:**	**PHY-601**	**Course Type**	**:**	**Core 1**
Contact Hours	**:**	**L- 40 T- 0 P- 0**	**Credit**	**:**	**4**
Program/Semester	**:**	**BTech/BDes/MTech/Mdes/PhD(NS)/ UG(6 semester onwards), PG (anysemester)**			
Pre-requisites	**:**	**NONE**			
Evaluation Scheme	**:**	**Quiz1-15%, Mid-Sem- 30%, Quiz2-15%, End-Sem- 40%,.**			

Course Details:

Module1:
Concepts of nanotechnology and biotechnology, transition from biotechnology to bionanotechnology, introduction of bionanomechanics, the legacy of evolution, structures and functions of biopolymers. **(10H)**

Module2:
DNA based nanostructures, metallic nanowires and DNA electronics including DNA computers, design and development of DNA based nanomaterials, physics based knowledge/physical principles governing DNA based nanotechnology. **(10H)**

Module3:
Protein based nanostructures, engineered nanopores, DNA-protein hybrid structures, nanomedicine.**(10H)**

Module4:
Polymer nano containers, bionanomaterials, nano-particle biomaterial hybrid systems, experimental and theoretical methods in bionanotechnology **(10H)**

References:

1. Nanobiotechnology, edited by CM Niemeyer and C.A. Mirkin, Edition-1, copyright © 2004 Wiley-VCH Verlag GmbH & Co. KGaA, Weinheim, Germany, ISBN-978-81-265-3840-9.
2. Bionanotechnology, edited by David S. Goodsell, Edition-1, copyright © 2004, Wiley-Liss, Inc. Hoboken, New Jersey, USA, ISBN-978-81-265-3836-2.
3. Nanobiotechnology and Nanobiosciences, edited by Claudio Nicolini, Edition-1, copyright © 2009, Stanford publishing Pvt. Ltd, Singapore, ISBN 978-98-142-4138-0.
4. Bionanotechnology, Maheshwar Sharon & Madhuri Sharon, Edition-1, copyright © 2012, CRC Press, Taylor & Francis groups, ISBN-978-14-398-5214-9.

Course Title	**:**	**Atomic and Molecular Physics**			
Course Code	**:**	**PHY-602**	**Course Type**	**:**	**Core 1**
Contact Hours	**:**	**L- 40 T- 0 P- 0**	**Credit**	**:**	**4**
Program/Semester	**:**	**BTech/BDes/MTech/Mdes/PhD(NS)/ UG(6 semester onwards), PG (anysemester)**			
Pre-requisites	**:**	**NONE**			
Evaluation Scheme	**:**	**Quiz1-15%, Mid-Sem- 30%, Quiz2-15%, End-Sem- 40%,.**			

Course Details:

Module1:
Quantum mechanics of hydrogen atom, angular momentum and parity, magnetic dipole moments, electron spin and vector atom model, spin-orbit interaction, hydrogen fine structure, identical particles and Pauli's principle. **(10H)**

Module2:
Multi-electron atoms, Hartree's field, atomic ground states, spectroscopic terms, L-S and J-J coupling, spectra of alkali and alkaline atoms, Zeeman effect, Stark effect, hyperfine structure of spectral lines, X-ray spectra. **(10H)**

Module3:
Types of molecular states and spectra, pure rotational spectra, vibrational-rotational spectra, Raman spectra, electronic spectra and Frank-Condon principle, isotope effect on electron spectra. **(10H)**

Module4:
Fluorescence and phosphorescence, classification of molecular electronic states, coupling of rotational and electronic motions, stability of molecular states, continuous and diffuse molecular spectra, concepts of LASER and its applications. **(10H)**

References:

1. Fundamentals of molecular spectroscopy edited by C.N. Banwel & E.M. McCas, 4th Edition, copyright © 1994, McGraw-Hill Education, UK, ISBN-978-0-07-462025-0.
2. Modern spectroscopy, edited by J.M. Hollas, 4th Edition, Copyright © 2004 by John Wiley & Sons Ltd, UK, ISBN- 0-470-84415-9.
3. Atomic and Molecular Spectra edited by Raj Kumar, Edition-13, Copyright © 2010, Campus book international publisher, India, ISBN-8-180-30035-8.
4. Introduction to Spectroscopy, edited by D.L. Pavia, G.M. Lampman, G.S. Kritz, & J.R. VyVyan, 5th edition, copyright © Cengage learning 2015, ISBN-13-978-1-285-46012-3.

Course Title	**:**	**Emerging Electronic Materials**.			
Course Code	**:**	**PHY 603**	**Course Type**	**:**	**Core 1**
Contact Hours	**:**	**L- 40 T- 0 P- 0**	**Credit**	**:**	**4**
Program/Semester	**:**	**PhD(NS/ECE (1st semester/ 2nd semester/3rd Semester)**			
Pre-requisites	**:**	**Solid State Physics/Materials Science**			
Evaluation Scheme	**:**	**Quiz1-15%, Mid-Sem- 30%, Quiz2-15%,End-Sem- 40%**			

Course Details:

Module1: Free electron theory and its failure, Band theory of solids, origin of band gaps in solids, energy bands in metals, semiconductors and insulators. Fermi level, intrinsic and extrinsic semiconductors, direct and indirect band gap materials. **(10H)**

Module2: Brillouin zone, real and reciprocal space, symmetry axes. Differences between bulk and nanomaterials, Electronic band structures and density of states for bulk and Nanostructures. **(10H)**

Module3: Smart Nanomaterials, Nanotubes, Nanowires and 2-D materials. Quantum confinement effects, interface scatterings, ballistic transport. Materials for organic electronics, OLEDs, Graphene based FETs. **(11H)**

Module4: Spintronics, Spin Filters, Giant Magneto Resistance (GMR) and Tunnel Magneto Resistance (TMR). Band gap engineering of nanomaterials for nano-devices, nano interconnects and sensors. Novel technological applications of nanomaterials. **(11H)**

References:

1. Introduction to Solid State Physics by C. Kittel (Willey Publications)
2. Introduction to Nanotechnology by Charles P. Poole and F. J. Owens (Willey Publications)
3. Electronic Transport in Mesoscopic Systems by S. Datta (Cambrige University Press)
4. Electronic Structure: Basic Theory and Practical Applications by Richard Martin (Cambrige University Press)

Course Title	**:**	**Electrodynamics**			
Course Code	**:**	**PHY-604**	**Course Type**	**:**	**Core 1**
Contact Hours	**:**	**L- 4 T- 0 P- 0**	**Credit**	**:**	**4**
Program/Semester	**:**	**PhD (NS) (1st semester/ 2nd semester/3rd Semester)**			
Pre-requisites	**:**	**NONE**			
Evaluation Scheme	**:**	**Quiz-15%, Mid-Sem- 30%,Quiz2-15%,End-Sem- 40%**			

Course Details:

Module 1: Coulomb's law and electrostatics, The energy of a continuous charge distribution, Laplace and Poisson equation, Uniqueness theorem, boundary value problems, method of images, dielectrics **(12H)**

Module 2: Steady currents and magnetostatics, The divergence and curl of B, Magnetic fields in matter, time varying fields and Faraday's law, Maxwell's equation, Maxwell's stress tensor, Poynting theorem **(12H)**

Module3: Electromagnetic waves in vacuum and matter, gauge transformations and gauge invariance, electromagnetic potentials, wave propagation in conductors and dispersive media, complex refractive index **(12H)**

Module4: Retarded potentials, Jefimanko's equations, Electric dipole radiation, magnetic dipole radiation, radiation from arbitrary source **(6H)**

References:

1. Introduction to Electrodynamics by David J Griffiths, Pearson Education India; 4th edition (2015) ISBN-10: 9332550441
2. Classical electrodynamics by J. D. Jackson, Wiley publisher; 3rd edition (2007) ISBN-10: 8126510943
3. Classical electrodynamics by W. Greiner, Springer international edition (2006) ISBN-10: 8181284577
4. Modern electrodynamics by Andrew Zangwill, Cambridge University Press (2012) ISBN-10: 0521896975

Course Title	**:**	**Quantum Mechanics**			
Course Code	**:**	**PHY-605**	**Course Type**	**:**	**Core 1**
Contact Hours	**:**	**L- 40 T- 0 P- 0**	**Credit**	**:**	**4**
Program/Semester	**:**	**PhD(NS/ECE (1st semester/ 2nd semester/3rd Semester)**			
Pre-requisites	**:**	**Solid State Physics/Materials Science**			
Evaluation Scheme	**:**	**Quiz1-15%, Mid-Sem- 30%, Quiz2-15%,End-Sem- 40%,**			

Course Details:

Module 1: The Schrodinger Equation, Normalization, Stationary States, The Infinite Square Well, The Harmonic Oscillator, The Free Particle, The Uncertainty Principle, bra and ket notation **(10H)**

Module 2: Schrodinger Equations in Spherical Coordinates, The Hydrogen Atom, Angular Momentum, concept of spin, Clebsch-Gordan coefficients, Identical particles-bosons and fermions, Quantum Statistical Mechanics. **(12H)**

Module3: Nondegenerate and degenerate time independent Perturbation Theory, The Fine Structure of Hydrogen, The Zeeman Effect, Hyperfined Splitting . **(12H)**

Module4: -WKB approximation, turning points, Tunneling, The Connection Formulas, time dependent perturbation theory, two level systems and theory of LASER . **(8H)**

References:

1. Introduction to Quantum Mechanics by David J Griffiths, Cambridge University Press India 2nd edition (2016) ISBN-10: 1316646513
2. Introductory quantum mechanics by R.L. Liboff, Pearson Education India 4th edition (2003) ISBN-10: 8131704416
3. Modern Quantum Mechanics by J.J. Sakurai, Pearson Education India 2nd edition (2013) ISBN-10: 9332519005
4. Feynman's Lectures on Physics Vol 3 by Richard Feynman, Pearson Education; First edition (2012) ISBN-10: 8131792137

Course Title	**:**	**Advanced Quantum Mechanics**			
Course Code	**:**	**PHY-606**	**Course Type**	**:**	**Core 1**
Contact Hours	**:**	**L- 3 T- 0 P- 0**	**Credit**	**:**	**4**
Program/Semester	**:**	**PhD (NS) (1st semester/ 2nd semester/3rd Semester)**			
Pre-requisites	**:**	**NONE**			
Evaluation Scheme	**:**	**Quiz1-15%, Mid-Sem- 30%, Quiz2-15%,End-Sem- 40%,**			

Course Details:

Module1: Introduction to quantum theory, Basic quantum mechanics, Operators, Eigen functions and Eigen values, Postulates, measurement and interpretation of quantum mechanics, Schrodinger's equations and applications. **(10H)**

Module2: The variation Principle, Simultaneous linear equations, Linear variation functions, Atomic units, The Born-Oppenheimer approximation, Electron spin, The antisymmetric Principle. **(10H)**

Module3: Spin and spatial orbitals, Hartree products, Slater determinants, Hartree-Fock approximation, Self-consistent field theory **(10H)**

Module4: Hartree-Fock equations, Coulomb and exchange operators, Fock operator, Minimization of energy of a single determinant, Koopman's theorem, Hartree-Fock Hamiltonian, Roothan's equation, Polyatomic basis sets.**(10H)**

References:

1. Introduction to Quantum mechanics by D.J. Griffiths, Publisher:Prentice Hall, New Jersey, USA, ISBN-0-13-124405-1.
2. Quantum Mechanics edited by Bransden Joachain, 2nd edition, published by Pearson Education, New Delhi, ISBN- 9788131708392.
3. Introductory Quantum mechanics edited by R.B. Liboff, 1st edition, published by Addison-Wesley USA, ISBN-0-201-12221-9, .
4. Quantum Chemistry edited by I.N. Levine, 7th edition, Published by Pearson publications, ISBN-978-0321803450
5. Modern Quantum Chemistry edited by A Szabo and N.S. Ostlund, published by Dover publications, ISBN- 978-048669186.

Course Title	**:**	**Condensed Matter Physics**			
Course Code	**:**	**PHY-607**	**Course Type**	**:**	**Core 1**
Contact Hours	**:**	**L- 3 T- 0 P- 0**	**Credit**	**:**	**4**
Program/Semester	**:**	**PhD (Physics) (1st semester/ 2nd semester/3rd Semester)**			
Pre-requisites	**:**	**NONE**			
Evaluation Scheme	**:**	**Quiz-10%, Mid-Sem- 20%, End-Sem- 40%, Project etc.-30%**			

Course Details:

Module1: Crystal structure of solids, reciprocal lattice, X-ray and electron diffraction, different methods for structure determination. **(9H)**

Module2: Crystal binding, cohesive energy. Lattice vibrations, Einstein and Debye models, phonons. Drude and Summerfeld models. **(11H)**

Module3: Block theorem, Empty lattice and nearly free electron model, tight-binding model, Brillouin zone, Density of states and Fermi surfaces. **(10H)**

Module4: Semiconductor crystals : intrinsic and extrinsic semiconductors, hole, effective mass, impurity band conduction , p-n junction, Shottky barrier, quantum Hall effect . **(11H)**

References:

1. C. Kittel, Introduction to solid state physics, 8th Edition, ISBN : 978-0-471-41526-8, 704 pages, October 2004, ©2005
2. N. Ashcroft and N.D. Mermin, Solid state physics, Cengage Learning, 2011, ISBN: 8131500527, 9788131500521, 826 pages
3. A.R.Verma and O.N.Srivastava, Crystallography applied to solid state physics, New Age International, 1991, Crystallography, ISBN: 8122403212, 9788122403213, 464 pages
4. J.R. Christman, Fundamentals of solid state physics. Wiley, 1988, ISBN: 0471633585, 9780471633587, 518 pages

Course Title	**:**	**Biophysics**			
Course Code	**:**	**PHY-609**	**Course Type**	**:**	**Core 1**
Contact Hours	**:**	**L- 3 T- 0 P- 0**	**Credit**	**:**	**4**
Program/Semester	**:**	**PhD (Physics) (1st semester/ 2nd semester/3rd Semester)**			
Pre-requisites	**:**	**NONE**			
Evaluation Scheme	**:**	**Quiz1-15%, Mid-Sem-30%, Quiz2:15% End-Sem-40%**			

Course Details:

Module1: Thermodynamics of Biological systems, Basic ideas on structures and functions of nucleic acids, proteins and carbohydrates, Biomolecular forces, DNA-Protein interaction, protein folding, Mechanisms of enzyme action and regulation. **(10H)**

Module2: DNA & protein modifications by free radicals, oxidative stress & radiation. Disorders in DNA and Proteins, Mutatgenesis, Carcinogenesis and aging. **(10H)**

Module3: Cancer initiation, promotion, & progression, Growth factors, growth factor receptors & signal transduction, Protein misfolding and aggregation, Neurodegenerative disorders, Alzheimer's disease, Parkinson's disease, Prion disease. **(10H)**

Module4: Enzymatic DNA repair, Chemical drug design by targeting protein-inhibitor binding, Biomaterials and applications, Molecular nanotechnology, Bio-nanomaterial & applications **(10H)**

References:

1. Lehninger Principles of Biochemistry edited by D. L. Nelson and M.M. Cox, 6th edition, publisher-W.H. Freeman and company, New York, ISBN-978-1-4292-3414-6
2. Biochemistry edited by R.H. Garett, C.M. Grisham. 5th edition, publisher-Nelson Education Ltd, Canada, ISBN 978-1133106296
3. The Molecular Biology of Cancer by M. Khan and S. Pelengaris. 1st edition, publisher-Wiley, Germany, ISBN: 978-1-4051-1814-9
4. Basic medical Biochemistry by C. Smith, A.D. Marks, M Lieberman, 2nd edition, publisher-Lippincott Williams & Wilkins, USA, ISBN- 9780781721455.

Course Title	**:**	**Nanotechnology for Engineers**			
Course Code	**:**	**PHY-611**	**Course Type**	**:**	**Core 1**
Contact Hours	**:**	**L- 3 T- 0 P- 0**	**Credit**	**:**	**4**
Program/Semester	**:**	**Ph.D students of NS, PG(ECE & ME)** **(7^{th} or 8^{th} semester of B.Tech, ALL semester of PG)**			
Pre-requisites	**:**	**NONE**			
Evaluation Scheme	**:**	**Quiz-10%, Mid-Sem- 20%, End-Sem- 40%, Project etc.-30%**			

Course Details:

Module1: Introduction to Nanostructured materials and Why nano world is different? Properties of Nanostructured materials (or nano-materials) based on mechanical, physical, chemical, optical, magnetic and electrical properties **(10H)**

Module2: Synthesis/fabrication of nano materials (physical and Chemical). Characterization of Nano matertals (X-ray diffraction, Scanning Electron Microscopy, Tunneling Electron Microscopy, Vibrating sample magnetometer, SQUID, Atomic Force Microscopy and Scanning tunneling microscopy) **(10H)**

Module3: Idea about Carbon based nano-materials. Development in- Plasmonics / Nanophotonics. and Spintronics (GMR, Spin Valve, and TMR) **(10H)**

Module4: - Current Trends in nanoelectronics and introduction to MEMS and microfluidics. **(10H)**

References:

1. Introduction to Nanotechnology: Charles P. Poole, Frank J. Owens, John Wiley & Sons (2003)
2. Nanotechnology A Gentle introduction to the Next Big Idea by Mark Ratner, D. Ratner: Pearson Education (2003)
3. Structural Nanocrystalline Materials Fundamentals and Applications: by C.C. Koch, I.A. Ovid'ko, S. Seal, S.Veprek: Cambridge University Press (2007).
4. Introduction to Nanoelectronics Science, Nanotechnology, Engineering, and Applications by V.V. Mitin, V.A. Kochelap, M.A. Stroscio: Cambridge University Press(2008).

Course Title	**:**	**Physics of magnetic materials**			
Course Code	**:**	**PHY-612**	**Course Type**	**:**	**Core 1**
Contact Hours	**:**	**L- 3 T- 0 P- 0**	**Credit**	**:**	**4**
Program/Semester	**:**	**PhD (NS) (1st semester/ 2nd semester/3rd Semester)**			
Pre-requisites	**:**	**NONE**			
Evaluation Scheme	**:**	**Quiz1-15%, Mid-Sem-30%, Quiz2:15% End-Sem-40%**			

Course Details:

Module 1: Field Production By Solenoids and electromagnets, Measurement of Field Strength, Vibrating-Sample Magnetometer, Alternating (Field) Gradient Magnetometer, SQUID Magnetometer, Permeameter, Susceptibility Measurements **(6H)**

Module 2: The Origin of Atomic Moments, Spin and Orbital States of Electrons, Theory of Diamagnetism and paramagnetism, ferromagnetism and Exchange Forces, Introduction to ferrimagnetism and antiferromagnetism. **(6H)**

Module 3: Anisotropy in single crystals and its physical origin, Anisotropy Measurement, Anisotropy in Polycrystalline Materials, Shape Anisotropy, Magnetostriction of Single Crystals and polycrystals, Physical Origin of Magnetostriction, Effect of Stress on Magnetostriction. **(6H)**

Module 4: Domain Wall Structure, Neel and Bloch domain walls, Magnetostatic Energy and Domain Structure, Single-Domain Particles, Micromagnetics, Domain Wall Motion and hindrances to it, Shapes of Hysteresis Loops **(12H)**

Module 5: Fine particles and thin films, Single-Domain vs Multi-Domain Behavior, Magnetization Reversal by Wall Motion, Superparamagnetism in Fine Particles, Exchange Anisotropy 6H

Module 6: magnetization dynamics, Domain Wall Velocity, Magnetic Damping, Magnetic Resonance, some soft and hard magnetic materials **(6H)**

References:

1. Introduction to Magnetic Materials by B. D. Cullity & C. D. Graham, Wiley-Blackwell; 2nd Revised edition (2008) ISBN-10: 0471477419
2. Physics of Magnetism and Magnetic Materials by K.H.J Buschow & F.R. de Boer, Springer; Softcover reprint of the original 1st ed. 2003 edition (2012) ISBN-10: 1475705670
3. Introduction to Magnetism and Magnetic Materials by David Jiles, CRC Press; 3rd edition (2015) ISBN-10: 148223887X
4. Magnetism and Magnetic Materials by J. M. D. Coey, Cambridge University Press 1st edition (2010) ISBN-10: 0521816149

Course Title	**:**	**Vacuum and Thin Film Technology**			
Course Code	**:**	**PHY-613**	**Course Type**	**:**	**Core 1**
Contact Hours	**:**	**L- 3 T- 0 P- 0**	**Credit**	**:**	**4**
Program/Semester	**:**	**PhD (1st semester/ 2nd semester/3rd Semester)**			
Pre-requisites	**:**	**NONE**			
Evaluation Scheme	**:**	**Quiz (10%), Mid Sem (20%), , End Sem (40%), Project etc-30%**			

Course Details:

Module1: Fundamentals of Vacuum Science
Kinetic theory of gases, mean free path, particle flux, monolayer formation, Gas's law; Elementary Gas Transport Phenomenon: Viscosity, diffusion, and thermal transpiration.
Viscous, molecular and Transition flow regimes, gas throughput, conductance, mass flow, pumping speed; Gas release from Solids: Vaporization, thermal desorption, virtual leaks, permeation, vacuum baking **(9 H)**

Module2: Generation, Measurement and Maintenance of Vacuum
Mechanical pumps (Rotary, Lobe and Turbomolecular pumps), Diffusion pump, Getter and Ion pumps, Cryopumps, Pump Fluids; Materials in Vacuum: Vaporization, out-gassing, glasses and Ceramics. Joints, Seals and Components, Gaskets and Motion feed through. McLeod gauge, thermal conductivity gauges, spin rotor gauge, diaphragm/capacitance gauges manometer, Ionization gauges, hot cathode, cold cathode gauges; Flow Meters and Residual Gas Analyzer, Leak Detection, How to design a vacuum system? **(12 H)**

Module3: Basics of Thin Film Growth
Definition and applications of thin films, Nucleation and Growth: Adsorption, Surface diffusion, models for 3D and 2D nucleation, coalescence and depletion, Role of energy enhancement in nucleation; Self-assembly: mechanisms and controls for nanostructures of 0 and 1 dimension.
Epitaxy: Structural aspects of epitaxy, homo- and hetero-epitaxy, lattice misfit and imperfections; theories of epitaxy, Role of interfacial layer, Band-gap engineering, Superlattice structures; Strained layer epitaxy. **(11 H)**
Module4: Techniques of Thin Film Deposition and Characterizations
Glow discharge and plasmas-Plasma structure, DC, RF and microwave excitation; Sputtering processes-Mechanism and sputtering yield, Sputtering of alloys; Reactive sputtering, CVD Deposition-Thermodynamics of CVD, gas transport, and growth kinetics, Morphological, Structural, Optical, and Electrical measurements of thin films (case studies), Industrial Coatings. **(10 H)**

References:

1. John F. O'Hanlon, *A User's Guide to Vacuum Technology (3rd Edition),* John Wiley & Sons, 2003.
2. Marsbed H. Hablanian, *High Vacuum Technology - A Practical Guide,* Marcel Dekker Inc. 1990.
3. Roth, *Vacuum Technology,* Pergamon Press (Oxford) 1983.
4. Milton Ohring, *The Materials Science and Thin Films,* Academic Press 1992.
5. Donald L. Smith, *Thin Film Deposition: Principles and Practice,* McGraw Hill 1995
6. K. L. Chopra, *Thin Film Phenomena,* McGraw Hill 1969.

Additional Text/Reference books:

1. A Chambers, R K Fitch & B S Halliday, *Basic Vacuum Technology*, Institute of Physics Publishing, (Bristol & Philedelphia) 1998.
2. David J. Hucknall, *Vacuum Technology and Applications*, Butterworth-Heinemann (Oxford) 1991. Meisel and Glang, *Handbook of Thin Film Technology*, Academic Press 1970.

Course Title	**:**	**Molecular Simulations.**			
Course Code	**:**	**PHY-614**	**Course Type**	**:**	**Core 1**
Contact Hours	**:**	**L- 3 T- 0 P- 0**	**Credit**	**:**	**4**
Program/Semester	**:**	**PhD (NS) (1st semester/ 2nd semester/3rd Semester)**			
Pre-requisites	**:**	**NONE**			
Evaluation Scheme	**:**	**Quiz1-15%, Mid-Sem-30%, Quiz2:15% End-Sem-40%**			

Course Details:

Module1: Concepts of Theoretical Physics, Molecular properties: Equilibrium geometry, Total energy, Ionization potential, Electron affinity, Electron Probability density, Dipole moments, Atomic charges, Electrostatic potentials, Thermodynamical properties. **(10H)**

Module2: Density functional theory: Hoenberg-Kohn theorems, Kohn-Sham Theory, Exchange and correlation energy, Local density approximation, General gradient approximation, Hybrid density functional theory. Molecular properties by density functional theory. **(10H)**

Module3: Electron Correlation methods: Brief ideas on Moller-Plesset perturbation theory, Coupled cluster theory and Configuration integral Theory. **(10H)**

Module4: : Molecular Mechanics: Force field, Bonded and non-bonded interactions, Solvent dielectric models, Energy minimization, Periodic and non-periodic boundary conditions, Constant temperature and pressure dynamics, Basic statistical mechanics. **(10H)**

References:

1. Density-Functional Theory of Atoms and Molecules by R.G Parr and W. Yang.
2. A Chemist's Guide to Density Functional Theory, edited by W. Koch and M.C. Holthausen, 2nd edition, 2001, Publisher: Wiley, VCH, Germany, ISBN: 978-3-527-30372-4. .
3. Molecular Modelling: Principles and Applications by A.R. Leach. Publisher, Addison Wesley Longman Limited, England, 2001, 2nd edition, ISBN 0-582-38210-6.
4. Introduction to Molecular Simulation and Statistical Thermodynamics, edited by Thijs J.H. Vlugt, Jan P.J.M. van der Eerden, Marjolein Dijkstra, Berend Smit, Daan Frenkel, Publisher: Delft, The Netherlands, 2008, 1st edition, ISBN- 978-90-9024432-7.
5. Computational Chemistry and Molecular Modeling Principles and Applications, edited by K. I. Ramachandran, G Deepa and Krishnan Namboori. P.K., 2008, ISBN 978-3-540-77302-3 Publisher: Springer-Verlag GmbH, Germany.
6. Understanding Molecular Simulation: From Algorithms to Applications, edited by D. Frenkel, B. Smit, 1996, 1st edition, ISBN 0-12-267370-0

Course Title	**:**	**Professional and Communication Skill**			
Course Code	**:**	**HS501**	**Course Type**	**:**	**Core 1**
Contact Hours	**:**	**L- 1 T- 0 P- 2**	**Credit**	**:**	**2**
Program/Semester	**:**	**All PG Students**			
Pre-requisites	**:**	**NONE**			
Evaluation Scheme	**:**	**Quiz1-10%, Mid-Sem-20%, End-Sem-40%, Term paper/Project/Assignments- 30%**			

Course Details:

Module 1: Importance of EQ over IQ, Brain Structure, Male Brain – Female Brain, EQ and Effective Communication, Personality Quotient and Professional Ethics. **(12 H)**

Module2: Mind and Brain, Soft Skills and Master Mind Technique, Body Language **(10 H)**

Module3: Research and Technical Writing, Report Writing **(10 H)**

Module4: Good Presentations, GD, Interview, CV **(10 H)**

Text/Reference books:

1. Professional Communication- Aruna Koneru- Mac Graw Hill Communication -2008
2. Communication Skills for Professionals- Konar N- Printice Hall India Pvt. Ltd. – 2nd Edition (2011)
3. Body Language- A Guide for Professionals- Hedwig Lewis- SAGE Response
4. Professional Communication Paperback- Tyagi K- Prentice Hall India Pvt. Ltd. (2011)

Course Title	**:**	**Indian Philosophy and Literature in English**			
Course Code	**:**	**HS601**	**Course Type**	**:**	**Core 1**
Contact Hours	**:**	**L- 3 T- 0 P- 0**	**Credit**	**:**	**4**
Program/Semester	**:**	**All PG Students (2nd Semester)**			
Pre-requisites	**:**	**NONE**			
Evaluation Scheme	**:**	**Quiz1-15%, Mid-Sem-30%, Quiz2:15% End-Sem-40%**			

Course Details:

Module 1: Dr.S Radhakrishnan- (The Hindu View of Life (2 Chapters), An Idealist view of Life (1 Chapter), Mahatma Gandhi – Autobiography (2 Chapters) **(12 H)**
Module2: Swami Vivekananda- Microcosm and Macrocosm, Rabindranath Tagore (Three poems), Kabir (2 poems) **(10 H)**
M**odule3**: Ralph Waldo Emerson- The American Scholar (Some Portions), Self Reliance (Some Portions), Hamatreya, Brahma **(10 H)**
Module4: Henry David Thoreau- Civil Disobedience (Some portions), Christianity and Hinduism compared, Walden – three paras. **(10 H)**

References:

1. Mumukshananada, Swami, The Complete works of Swami Vivekananda, Calcutta: Swami Mumukashananda, 1994
2. Narayan, Shriman, The Selected works of Mahatma Gandhi, Ahmedabad: Navjivan Trust, 1997
3. Radhakrishnan, S, An Idelaist View of Life, New Delhi: Indua Publishers, 1994
4. Radhakrishnan, S, The Hindu View of Life, Mumbai: Blackie and Son Publishers, 1983
5. Tagore, Rabindranath, Gitanjali, New Delhi: Macmillian India Limited, 1997