School of Basic Sciences (Mathematics)

Q-Exam subject & Syllabus

Subject Code: MAXXXX	**Subject Name: Real Analysis**

Syllabus: Real number system and set theory: Completeness property, Archimedian property, Denseness of rationals and irrationals, Countable and uncountable, Cardinality, Zorn's lemma, Axiom of choice. Metric spaces: Open sets, Closed sets, Continuous functions, Completeness, Cantor intersection theorem, Baire category theorem, Compactness, Totally boundedness, Finite intersection property. Riemann-Stieltjes integral: Definition and existence of the integral, Properties of the integral, Differentiation and integration. Sequence and Series of functions: Uniform convergence, Uniform convergence and continuity, Uniform convergence and integration, Uniform convergence and differentiation. Equicontinuity, Ascoli's Theorem, Weierstrass approximation theorem.

Text Books:

1. Apostol T. *Mathematical Analysis*, Narosa Publishers
2. Rudin W. *Principles of Mathematical Analysis*, McGraw-Hill

Reference Books:

1. Hewitt E. and Stomberg K. *Real and Abstract Analysis: A Modern Treatment of the Theory of Functions of a Real Variable*, Springer
2. K. Ross K. *Elementary Analysis: The Theory of Calculus*, Springer
3. Royden H. L. *Real Analysis*, Prentice Hall of India
4. Tao T. *Analysis-I and II*, Hindustan Book Agency

Subject Code: MAXXXX	**Subject Name: Complex Analysis**

Syllabus: Polar representation and roots of complex numbers; Spherical representation of extended complex plane; Elementary properties and examples of analytic functions: The exponential, Trigonometric functions, Mobius transformations, Cross ratio; Complex integration: Power series representation of analytic functions, Zeros of analytic functions, Cauchy theorem and integral formula, The index of a point with respect to a closed curve, the general form of Cauchy's theorem; Open Mapping Theorem; Classification of singularities: Residue theorem and applications; The Argument Principle; The Maximum modulus Principle; Schwarz's lemma; Phragmen-Lindelof theorem.

Text Books:

1. Conway J. B. *Functions of One Complex Variable,* Narosa, New Delhi
2. Ahlfors L. V. *Complex Analysis*, McGraw Hill

Reference Books:

1. Gamelin T.W. *Complex Analysis*, Springer International Edition

2. Churchill R.V. and Brown J.W. *Complex Variables and Applications*, McGraw Hill
3. Rudin W. *Real and complex analysis*, McGraw-Hill Book Co

Subject Code: MAXXXX	**Subject Name: Algebra**

Syllabus: Groups: Binary operation and its properties, Definition of a group, Examples and basic properties, Subgroups, Cyclic groups, Dihedral Groups, Permutation groups, Cayley's theorems. Coset of a subgroup, Lagrange's theorem, Order of a group, Normal subgroups, Quotient group,

Homomorphisms, Kernel Image of a homomorphism, Isomorphism theorems, Direct product of groups, Group action on a set, Semi-direct product, Sylow' theorems, Structure of finite abelian groups. Rings: Definition, Examples and basic properties. Zero divisors, Integral domains, Fields. Characteristic of a ring, Quotient field of an integral domain. Subrings, Ideals, Quotient rings, Isomorphism theorems, Ring of polynomials. Prime, Irreducible elements and their properties, UFD, PID and Euclidean domains. Prime ideal, Maximal ideals, Prime avoidance theorem, Chinese remainder theorem.

Fields: Field of fractions, Gauss lemma, Fields, field extension, Galois theory.

Text Books:

1. Gilbert W. J. and Nicholson W. K. *Modern Algebra with Applications*, Wiley
2. Dummit D. and Foote R. *Abstract Algebra*, Wiley

Reference Books:

1. Artin. *Algebra*, Prentice-Hall of India
2. Herstein, *Topics in Algebra*, Wiley
3. Herstein, *Abstract Algebra*, Wiley
4. Gallian, *Contemporary Abstract Algebra*, Narosa
   Fraleigh J. B. *A First Course in Abstract Algebra*, Pearson

Subject Code: MAXXXX	**Subject Name: Linear Algebra**

Syllabus: Vector spaces over fields, subspaces, bases and dimension; Systems of linear equations, matrices, rank, Gaussian elimination; Linear transformations, representation of linear transformations by matrices, rank-nullity theorem, duality and transpose; Determinants, Laplace expansions, cofactors, adjoint, Cramer's Rule; Eigenvalues and eigenvectors, characteristic polynomials, minimal polynomials, Cayley-Hamilton Theorem, triangulation, diagonalization, rational canonical form, Jordan canonical form; Inner product spaces, Gram-Schmidt orthonormalization, orthogonal projections, linear functionals and adjoints, Hermitian, self-adjoint, unitary and normal operators, Spectral Theorem for normal operators; Rayleigh quotient, Min-Max Principle. Bilinear forms, symmetric and skew-symmetric bilinear forms, real quadratic forms, Sylvester's law of inertia, positive definiteness.

Text Books:

1. Axler S. *Linear Algebra Done Right*, UTM, Springer
2. K. Hoffman and R. Kunze, Linear Algebra, Pearson Education
3. S. Lang, Linear Algebra, Undergraduate Texts in Mathematics, Springer-Verlag, NewYork**.**

Reference Books:

1. Artin M. *Algebra*, Prentice Hall of India
2. Rose H.E. *Linear Algebra*, Birkhauser
3. Strang G. *Linear Algebra and its applications*, Cengage Learning

Subject Code: MAXXXX	**Subject Name: Discrete Mathematics**

Syllabus: Set theory: sets, relations, functions, countability; Logic: formulae, interpretations, methods of proof, soundness and completeness in propositional and predicate logic; Number theory: division algorithm, Euclid's algorithm, fundamental theorem of arithmetic, Chinese

remainder theorem, special numbers like Catalan, Fibonacci, harmonic and Stirling; Combinatorics: permutations, combinations, pigeonhole principle, inclusion and exclusion principle, partitions, recurrence relations, generating functions; Graph Theory: paths, connectivity, subgraphs, isomorphism, trees, complete graphs, bipartite graphs, matchings, colourability, planarity, digraphs, Eulerian cycle and Hamiltonian cycle, adjacency and incidence matrices.

Text Books:

1. Rosen K. H. *Discrete Mathematics & its Applications*, Tata McGraw-Hill
2. Balakrishnan V. K. *Introductory Discrete Mathematics*, Dover

Reference Books:

1. Liu C. L. *Elements of Discrete Mathematics*, Tata McGraw-Hill
2. Grimaldi R. P. *Discrete and Combinatorial Mathematics*, Pearson Education
3. Burton D. M. *Elementary Number Theory*, McGraw Hill
4. Deo N. *Graph Theory*, Prentice Hall of India

Subject Code: MAXXXX	**Subject Name: Functional Analysis**

Syllabus: Fundamentals of normed linear spaces: Normed linear spaces, Riesz lemma, characterization of finite dimensional spaces, Banach spaces. Bounded linear maps on normed linear spaces: Examples, linear map on finite dimensional spaces, finite dimensional spaces are isomorphic, operator norm. Hahn-Banach theorems: Geometric and extension forms and their applications. Three main theorems on Banach spaces: Uniform boundedness principle, divergence of Fourier series, closed graph theorem, projection, open mapping theorem, comparable norms. Dual spaces and adjoint of an operator: Duals of classical spaces, weak and weak* convergence, Banach Alaoglu theorem, adjoint of an operator. Hilbert spaces: Inner product spaces, orthonormal set, Gram-Schmidt ortho-normalization, Bessel's inequality, Orthonormal basis, Separable Hilbert spaces. Projection and Riesz representation theorem: Orthonormal complements, orthogonal projections, projection theorem, Riesz representation theorem. Bounded operators on Hilbert spaces: Adjoint, normal, unitary, self adjoint operators, compact operators, eigenvalues, eigen vectors, Banach algebras. Spectral theorem: Spectral theorem for compact self adjoint operators, statement of spectral theorem for bounded self adjoint operators.

Text Books:

1. Kreyzig E. *Introduction to Functional Analysis with Applications*, John Wiley & Sons
2. Conway J. B. *A Course in Functional Analysis*, Springer, Berlin

Reference Books:

1. Limaye B.V. *Functional Analysis*, New Age International
2. Taylor A. and Lay D. *Introduction to Functional Analysis*, Wiley
3. Rudin W. *Functional analysis*, McGraw-Hill
4. Goffman C. and Pedrick G. *A First Course in Functional Analysis*, Prentice-Hall

Subject Code: MAXXXX	**Subject Name: Topology**

Syllabus: Topological spaces, Basis and subbasis, The order topology, Subspace topology, Closed sets. Countability axioms, Limit points, Convergence of nets in topological spaces, Continuous functions, homomorphisms. The product topology, box topology, Metric topology, Quotient topology. Connected spaces, Connected sets in R, Components and path components, Compact spaces, Compactness in metric spaces, Local compactness, One-point compactification. Separation axioms, Uryshon's lemma, Uryshon's metrization theorem, Tietz extension theorem. The Tychonoff theorem, Completely regular spaces, Stone-Cech compactification.

Text Books:

1. Munkres J.R. *Topology*, Pearson Education
2. M. A. Armstrong, Basic Topology, Springer
3. G.F. Simmons, Introduction to Topology and Modern Analysis, McGraw-Hill

Reference Books:

1. Royden H. L. *Real Analysis,* Prentice Hall of India
2. Kelley J.L. and Nostrand V. *General Topology*, Princeton

Subject Code: MAXXXX	**Subject Name: Ordinary and Partial Differential Equations**

Syllabus: Ordinary differential equations: first order equations, Picard's theorem (existence and uniqueness of solution to first order ordinary differential equation). Second order differential equations- second order linear differential equations with constant coefficients. Systems of first order differential equations, equations with regular singular points, stability of linear systems. Introduction to power series and power series solutions. Special ordinary differential equations arising in physics and some special functions (e.g. Bessel's functions, Legendre polynomials, Gamma functions) and their orthogonality. Oscillations - Sturm Liouville theory. Mathematical models leading to partial differential equations. First order quasi-linear equations. Nonlinear equations. Cauchy-Kowalewski's theorem (for first order). Classification of second order equations and method of characteristics. Riemann's method and applications. One dimensional wave equation and D'Alembert's method. Vibration of a membrane. Duhamel's principle. Solutions of equations in bounded domains and uniqueness of solutions. BVPs for Laplace's and Poisson's equations. Maximum principle and applications. Green's functions and properties. Existence theorem by Perron's method. Heat equation, Maximum principle. Uniqueness of solutions via energy method. Uniqueness of solutions of IVPs for heat conduction equation. Green's function for the heat equation. Finite difference method for the existence and computation of solution of heat conduction equation.

Text Books:

1. Coddington E. A. *An Introduction to Ordinary Differential Equations*, Prentice Hall
2. *Differential Equations*, Tata McGraw Hill
3. Sneddon I. N. *Elements of Partial Differential Equations*, McGraw Hill
4. John F. *Partial Differential Equations*, Springer Verlag

Reference Books:

1. Hsieh P.F. and Sibuya Y. *Basic Theory of Ordinary Differential Equations*, UTX, Springer
2. Ross S. L. *Differential Equations*, Wiley
3. Willams W. E. *Partial Differential Equations*, Oxford
4. Strauss W.A. *Partial Differential Equations: An Introduction*, John Wiley
5. Folland G. B. *Introduction to partial differential equations*, Princeton University Press
6. Rauch J. *Partial differential equations*, Graduate Texts in Mathematics, 128. Springer-Verlag

Subject Code: MAXXXX	**Subject Name: Probability and Statistics**

Syllabus:

Probability:-Axiomatic definition, Properties. Conditional probability, Bayes rule and independence of events. Random variables, Distribution function, Probability mass and density functions, Expectation, Moments, Moment generating function, Chebyshev's inequality. Special distributions: Bernoulli, Binomial, Geometric, Negative Binomial, Hypergeometric, Poisson, Uniform, Exponential, Gamma, Normal, Joint distributions, Marginal and conditional distributions, Moments, Independence of random variables, Covariance, Correlation, Functions of random variables, Weak law of large numbers, P. Levy's central limit theorem (i.i.d. finite variance case), Normal and Poisson approximations to binomial.

Statistics:-Introduction: Population, Sample, Parameters. Point Estimation: Method of moments, MLE, Unbiasedness, Consistency, Comparing two estimators (Relative MSE). Confidence interval estimation for mean, difference of means, variance, proportions, Sample size problem, Test of

Hypotheses:-N-P Lemma, Examples of MP and UMP tests, p-value, Likelihood ratio test, Tests for means, variance, Two sample problems, Test for proportions, Relation between confidence intervals and tests of hypotheses, Chi-square goodness of fit tests, Contingency tables, SPRT, Regression Problem:- Scatter diagram, Simple linear regression, Least squares estimation, Tests for slope and correlation, Prediction problem, Graphical residual analysis, Q-Q plot to test for normality of residuals, Multiple regression, Analysis of Variance: Completely randomized design and randomized block design, Quality Control: Shewhart control charts and Cusum charts.

Text Books:

1. Grimmett G. R. and Stirzaker D. R. *Probability and Random Processes*, Oxford University Press
2. Douglas C. Montgomery and George C. R. *Applied Statistics and Probability for Engineers*, Wiley
3. Miller & Freund's. *Probability and Statistics for Engineers*, Pearson-Prentice Hall

Reference Books:

1. Ross S. M. A *First Course in Probability*, Prentice- Hall
2. Larson H. J. *Introduction to Probability Theory and Statistical Inference*, Wiley
3. Rohatgi V. K. *An Introduction to Probability Theory and Mathematical Statistics,* John Wiley & Sons
4. Feller W. *Introduction to Probability Theory and its applications*, Vol I, Wiley
5. Gun A. M., Gupta M. K., and Das Gupta B. *Fundamentals of Statistics*,
6. Gun A. M., Gupta M. K., and Das Gupta B. *Outline of Statistics*

Subject Code: MAXXXX	**Subject Name: Number Theory**

Syllabus: Congruences: linear and polynomial congruences; prime numbers: counting primes, numbers of special forms, pseudo-primes and primality testing; factorization: factorization algorithms; arithmetic functions: multiplicative and additive functions, Euler's phi function, sum and number of divisors functions, the Mobius function and other important arithmetic functions, Dirichlet products; primitive roots and quadratic residues: primitive roots, index arithmetic, quadratic residues, modular square roots; Diophantine equations: linear Diophantine equations, Pythagorean triples, Fermat's last theorem, Tell's, Bachet's and Catalan's equations, sums of squares; Diophantine approximations: continued fractions, convergent, approximation theorems; quadratic fields: primes and unique factorization.

Text Books:

1. Koshy, *Elementary Number Theory with Applications*, Academic Press
2. Burton D.M. *Elementary Number Theory*, McGraw Hill

Reference Books:

1. Rosen K. H. *Elementary Number Theory (and its applications*, Pearson Addison- Wesley
2. Niven I., Zuckerman H. S. and Montgomery, H.L. *An Introduction to the Theory of Numbers*, Wiley
3. Chandrasekaran K. *An Introduction to Analytic Number Theory*, Springer

4. Hardy G.H. and Wright E.M. *An introduction to the Theory of Numbers*, Oxford University Press

Subject Code: MAXXXX	**Subject Name: Numerical Analysis**

Syllabus: Definition and sources of errors, Propagation of errors, Backward error analysis, Sensitivity and conditioning, Stability and accuracy, Floating-point arithmetic and rounding errors. Nonlinear equations, Bisection method, Newton's method and its variants, Fixed point iterations, Convergence analysis. Newton's method for nonlinear systems. Finite differences, Polynomial interpolation, Hermite interpolation, Spline interpolation, B-splines. Numerical integration, Trapezoidal and Simpson's rules, Newton-Cotes formula, Gaussian quadrature, Richardson Extrapolation IVP: Taylor series method, Euler and modified Euler methods, Runge- Kutta methods, Multistep methods, Predictor-Corrector Method Accuracy and stability, Solution for Stiff equations BVP: Finite difference method.

Text Books:

1. Conte S. D. and Boor C. D. *Elementary Numerical Analysis - An Algorithmic Approach*, McGraw Hill

Reference Books:

1. Heath M. T., *Scientific Computing: An Introductory Survey*, McGraw Hill
2. Atkinson K. E. *Introduction to Numerical Analysis,* John Wiley
3. Gerald C. F. and Wheatley P. O. *Applied Numerical Analysis*, Addison Wesley

School of Basic Sciences

Discipline: Physics

Q-Exam subject & Syllabus

Subject Code:	**Subject Name:** Fundamental Classical Mechanics

Syllabus:

Newtonian mechanics, central forces, collisions, rigid body dynamics. Generalized coordinates, constraints, Lagrangian mechanics for conservative and dissipative systems, small oscillations, forced oscillators, anharmonic oscillators, perturbation theory. Hamiltonian formalism, phase space & phase trajectories, canonical transformations, Poisson brackets, Hamilton-Jacobi theory, action angle variables. Special Relativity, Lorentz transformations, relativistic kinematics and mass-energy equivalence.

Text Books:

1. Goldstein H., Poole Jr C. P., Safko J. L., *Classical Mechanics,*Addison-Wesley.

Reference Books:

2. Landau L. and Lifshitz E., *Mechanics* Butterworth-Heinemann.
3. Resnick R., *Introduction to Special Relativity,* John Wiley (Asia).
2. Morse Philip, Feshbach Herman, *Methods of Theoretical Physics, Parts 1 and 2*, Feshbach Publishing

Subject Code:	**Subject Name:** Fundamental of Quantum Mechanics

Syllabus:

Formalism: Linear vector spaces, states and observables, Hermetian operators; Time-Independent Schrodinger equation; Particle in a box; Harmonic oscillator and coherent states; scattering from rectangular barriers: quantum tunnelling; Finite well; Delta-Function potential; Angular momentum and spin; Angular momentum addition; Spin in a magnetic field; Hydrogen atom; Time-independent perturbation theory: Fine structure of the hydrogen atom spectra; WKB approximation; Variational principle; Identical particles

Text Books:

1. Leonard I Schiff, *Quantum Mechanics*
2. David J Griffiths; *Introduction to Quantum Mechanics*

Reference Books:

3. Richard L. Liboff, *Introductory Quantum Mechamics*
4. Claude Cohen-Tannoudji, Bernard Diu and Franck Laloe; *Quantum Mechanics*

Subject Code:	**Subject Name:** Basics of Detection and measurement of High energy particle and radiation

Syllabus:

Passage of radiation through matter: Interaction of charged particles, neutrons, gamma rays, ionisation loss characterised by the Bethe-Bloch equation, loss via bremsstrahlung, and the Cherenkov effect, Characteristics of detectors, Gas filled detectors, Scintillation counters, Solid state detectors, Drift Chambers, Basics of Accelerator Physics, Cyclotrons, Synchrotrons, Colliders

Text Books:

1. Knoll Glenn F., *Radiation Detection and Measurements,* John Wiley and Sons.

Reference Books:

2. Leo W. R., *Techniques for Nuclear and Particle Physics Experiments*, Springer Verlag.

Subject Code:	**Subject Name:** Fundamental of Semiconductor devices

Syllabus:

Material overview and classification, energy band formation, effective mass of electrons and holes, carrier density, Fermi level, donor and accepter impurities, Hall effect, generation and recombination of carriers, thermal motion of the carriers, carriers under electric field, mobility, drift current, diffusion current, P-N junction, depletion approximation, electric field at junction, energy band diagram, Junction Break down, Metal-Semiconductor junction, MOS capacitor, Quality analysis of field effect, electric field and potential diagram, Gate voltage drop across a MOS device, capacitance - voltage measurement Photo conductivity, Heterojunction, LED device and LED characteristics, solar cell, , Single electron tunnelling devices

Text Books:

1. Chihiro Hamaguchi; *Basic Semiconductor Physics*
2. Donald A Neamen, *Semiconductor Physics and Devices*

Reference Books:

3. Maticus Grundmann, *The Physics of Semiconductor*

Subject Code:	**Subject Name:** Numerical Techniques

Syllabus:

Random numbers, curve fitting, linear algebra and matrix manipulations, inversion, diagonalization, eigenvectors and eigenvalues, integration of initial-value problems, sorting, interpolation, extrapolation, regression, numerical integration, quadrature, Euler, Runge-Kutta, and Verlet schemes, root searching, Monte Carlo methods.

Text Books:

1. W.H. Press, B.P. Flannery, S.A. Teukolsky and W.T. Vetterling, *Numerical Recipes: The Art of Scientific Computing*, Cambridge University Press
2. Frenkel and Smith, Understanding Molecular Simulations, Elsevier

Reference Books:

3. H.M. Antia, *Numerical Methods for Scientists and Engineers*, Hindustan Book Agency

Subject Code:	**Subject Name:** Statistical Mechanics

Syllabus:

Canonical (CE) and Grand-canonical Ensemble (GCE) : Probability distribution in CE and GCE; Thermodynamic quantities in CE and GCE; Energy dispersion in CE; Mean particle number and mean energy and the grand potential; Fluctuations in particle number; Some applications . Ideal quantum gases; Fermions and Boson, Photons and Phonons; Bose-Einstein Condensation, Chandrasekhar limit Thermodynamics of phase transitions, metastable states, Van der Waals' equation of state, coexistence of phases, Landau theory, critical phenomena at second-order phase transitions, scaling hypothesis, critical exponents, Ising model, mean-field theory, exact solution in one dimension, renormalization in one dimension. Brownian motion, Langevin equation, fluctuation-dissipation theorem, Einstein relation, Time correlation functions, linear response theory, and the Kubo formula

Text Books:

1. K. Huang, *Statistical Mechanics*, Wiley
2. R.K. Pathria, *Statistical Mechanics*, Elsevier

Subject Code:	**Subject Name:** Solid State Physics

Syllabus:

Crystal lattice, Reciprocal lattice, X-ray diffraction, Neutron scattering, Basic of Drude model,Boltzmann transport equation, scattering and relaxation time. Optical properties of solids, excitations, concept of plasmons, polarons and polaritons. Dielectric function, dielectric and ferroelectric materials. Band structure of semiconductors, density of states and conductivity effective masses, carrier diffusion processes, excess carrier life time,recombination and trap centres, photo conductivity, electronic properties of surfaces. Dia, para and ferro magnetism, magnetic domains, magnetic materials and application. Magnetic resonance techniques, spin-spin and spin-lattice relaxation. Superconductivity, Meissner effect, tunneling in superconductors, Josephson junctions, squids, superconducting magnets.

Text Books:

1. N. Ashcroft and N.D. Mermin, *Solid state physics*
2. C. Kittel, *Introduction to solid state physics,*

Reference Books:

3. J. R. Christman, *Fundamentals of Solid State Physics*
4. Ibach and Luth, *Solid State Physics,*

Subject Code:	**Subject Name:** Fundamentals of Atomic Physics

Syllabus:

Atomic hydrogen, multi-electron atom, Fine structure splitting, hyperfine structure, LS and JJ coupling, Zeeman effect, Symmetric and antisymmetric wave functions, Hartree-method, Born approximation.

Text Books:

1. Bransden B. H. and Joachain C.J., *Physics of atoms and molecules,* Longman Scientific & Technical.
2. Griffiths David J., *Introduction to Quantum Mechanics,* Pearson Education Inc.2

Reference Books:

3. Beiser Arthur, *Concepts of Modern Physic,* McGraw Hill Education
4. Banwell C. N. and McCash E. M., *Fundamentals of Molecular Spectroscopy,* McGraw-Hill College.

Subject Code:	**Subject Name:** Fundamentals of Magnetism and Superconductivity

Syllabus:

Magnetism: Classification of magnetic materials; localized and itinerant magnetism; various types of exchange interactions- direct, super, RKKY and DM; magneto-crystalline anisotropy energy; shape anisotropy; domains, domain walls and magnetization process; Superconductivity: Overview; types of superconductors; electrodynamics and thermodynamics of superconductors; Elements of Ginzburg-Landau theory and BCS theory; Fluxoid quantisation; Giaever tunnelling; Josephson tunnelling; principle of quantum

interference; applications of superconductivity; SQUID, recent discoveries on high temperature superconductors.

Text Books:

1. Magnetism in Condensed Matter - Stephen Blundell, Oxford Master Series 2001
2. Magnetism and Magnetic Materials – J M D Coey, Cambridge University Press 2012
3. Superconductivity, Superfluids and Condensates - J F Annet, Oxford Master Series 2004

Reference Books:

4. Physics of Ferromagnetism - S. Chikazumi, Oxford University Press 1997
5. Superconductivity - C Poole, H Farach and R Creswick, R Prozorov , Elsevier 2014

Subject Code:	**Subject Name:** Fundamentals of Classical Electrodynamics

Syllabus:

The laws of electrodynamics, differential and integral form of Maxwell equations, scalar and vector potential, gauge transformations, solutions of Maxwell equations, Green functions, Neumann and Dirichlet boundary conditions, vacuum solutions and solutions in the presence of charges and currents, Reflection and refraction of electromagnetic waves, retarded potentials, Jefimenko's equations, Liénard-Wiechert potentials, radiation emission by moving charges. Dipole fields, Transmission lines, Waveguides, Antennas and Arrays.

Text Books:

1. Introduction to Electrodynamics, D. J. Griffiths
2. J. D. Jackson, Classical Electrodynamics, John Wiley and Sons 1998

Reference Books:

3. E. K. Jordan and K. G. Balmain, Electromagnetic Waves and Radiating Systems, Prentice Hall 1971
4. S. S. Puri, Classical Electrodynamics, Tata McGraw Hill 1997

Subject Code:	**Subject Name:** Material Characterization

Syllabus:

Scanning electron microscopy: beam-sample interaction, Interaction volume concept, WDS, EDS, EPMA techniques and their application; X-ray diffraction – crystal, powder, grazing incidence; Electron Energy Loss Spectroscopy; Surface analysis methods: AES, XPS, AFM, STM; Transmission electron microscopy: sample preparation, bright field and dark field imaging.

Text Books:

1. D. John O'Connor, Brett A. Sexton, Roger St. C. Smart, Surface Analysis Methods in Materials Science, Springer.
2. J. Goldstein, D.E. Newbury, D.C. Joy, C.E.Lyman,P.Echlin,E. Lifshin, L. Sawyer, J.R. M L

Sawyer, J R Michael, Scanning Electron Microscopy and X-ray Microanalysis.
3. David B. Williams, C.Barry Carter, Transmission Electron Microscopy: A Textbook for Materials Science (4 Vol. Set).

Reference Books:

4. B.D. Cullity, C.R. Stock, Elements of X-Ray Diffraction
5. Bert Voigtländer, Scanning Probe Microscopy: Atomic Force Microscopy and Scanning Tunneling Microscopy (NanoScience and Technology), Springer.

Subject Code:	**Subject Name:** Optics and Laser		

Syllabus:

Superposition of waves, Coherence theory, Concept of spatial and temporal coherence, Diffraction theory, Interferometry and its applications, Optical fiber and waveguides, Basic Physics and characteristic of laser, Spontaneous and stimulated emission of radiation, line shape function, condition for amplification, optical resonators.

Text Books:

1. Hecht E., Optics, Addison-Wesley.
2. Ghatak A., Optics, McGraw-Hill.

Reference Books:

4. Siegman A. E., Lasers, University Science Books.
5. O. Svelto, Principles of Lasers, Springer.
6. Thyagarajan K. and Ghatak, Lasers, Theory and Applications, Springer.

School of Basic Sciences

Q-Exam Subjects and Syllabus (Chemistry and Biosciences)

Subject Code: CYQ016	**Subject Name:** Mathematics for Biologists (Compulsory)

Syllabus: Probability and Statistics: Mean, median, mode and standard deviation; Confidence Interval; T-test; Chi square test; Random variables; Poisson, normal and binomial distributions; Frequency and Probability distribution; **Correlation and regression analysis:** Solution of linear and nonlinear algebraic equations; Coordinate systems and transformations; Mathematical modeling of biomolecules

Text and Reference Books

1. Mathematics for Biological Scientists, M. Aitken, B. Broadhursts, S. Haldky, Garland Science (2009)
2. Molecular Modelling: Principles and Applications, Andrew R. Leach

Subject Code: CYQ001	**Subject Name:** Heterocyclic Chemistry

Syllabus: Introduction to heterocyclic and polyheterocyclic compounds, synthesis and reactivity of pyrrole, furan, thiophene, Indole, Quinoline, Isoquinoline, 1,2- and 1,3-azoles, triazoles, Purines and pyrimidines. Synthesis of benzo-fused heterocycles and similar compounds, Heterocyclic compounds in natural products, medicines and agrochemicals.

Text and Reference Books

1. Joule, J. A. and Mills, K. Heterocyclic Chemistry, Fifth Edition, Wiley.
2. Gilchrist, T. L., Heterocyclic Chemistry, Prentice Hall.

Subject Code: CYQ002	**Subject Name:** Spectroscopy for Chemist

Syllabus: UV-Visible spectroscopy: Basic Theory, Beer-Lambert's Law, Analysis of the spectrum, chromophore, auxochrome, and their interaction. General application with emphasis on chromophore detection

IR spectroscopy: Basic theory, selection rule, types and vibrational modes of freedom, Fingerprint and functional group region. General applications with emphasis on qualitative identification of functional groups. Characteristic vibrational frequencies of alkanes, alkenes, alkynes, aromatic compounds, alcohols, ethers, phenols, amines; Detailed study of vibrational frequencies of carbonyl compounds (ketones, aldehydes, esters, amides, acid anhydrides, lactones, lactams, conjugated carbonyl compounds); Effects of H-bonding and solvent effect on vibrational frequency, extension to various organic molecules for structural assignment

NMR spectroscopy: Basic principles of Proton Magnetic Resonance, chemical shift and factors influencing it; Spin – Spin coupling and coupling constant; Anisotropic effects in alkene, alkyne, aldehydes and aromatics, Dynamic effects in proton NMR, Analysis of high-resolution NMR spectra. Introduction to ^{13}C NMR, comparison between proton and ^{13}C NMR, sensitivity, proton decoupled ^{13}C NMR, DEPT. NOE, 2D NMR (COSY, INADEQUATE, HMQC, HSQC, HMBC, NOESY, HETCOR, ROESY, TOCSY).

Mass Spectroscopy: Basic principle, Ion sources (EI, CI, Field Ionization, FAB, Plasma desorption, Field desorption, Laser desorption, MALDI, Thermospray, API, ESI, APCI, APPI, Mass analyzers (Quadrople, Ion trap, ToF, Orbitrap, magnetic and electromagnetic analyzers), molecular peak,

McLafferty rearrangements, the fragmentation pattern of simple organic compounds with respect to their structure determination.
Applications of IR, Mass and NMR for structural elucidation with exhaustive examples.

Text and Reference Books

1. NMR Spectroscopy: Basic Principles, Concepts, and Applications in Chemistry by Harald Gunther; Third Edition; Wiley VCH 2013.
2. Spectrometric Identification of Organic Compounds, Robert M. Silverstein, Francis X. Webster, David J. Kiemle, David L. Bryce; 8th Edition; Wiley 2014
3. Fundamentals of Molecular Spectroscopy By Colin N. Banwell, Fourth edition; McGraw-Hill 2017
4. Introduction to Spectroscopy by Donald L. Pavia, Gary M. Lampman, George S. Kriz, James R. Vyvyan; Fifth Edition; Cengage Learning 2015

Subject Code: CYQ003	**Subject Name:** Fundamentals of Polymer Chemistry

Syllabus: Polymers definition and classification; Types of polymerization; Synthesis of various commercially important polymers; Stereo chemistry and mechanism of polymerization; Polymerization techniques; Polymer processing techniques; Polymer Characterization: molecular weight studies and molecular weight distribution; Polymer behaviour; Crystalline and thermal behaviour, glass transition temperature.

Text and Reference Books

1. Billmeyer F. W. "Text book of Polymer Science", published by Johns Wiley & Sons.
2. George Odian. "Principles of Polymerization" published by Wiley-Interscience.

Subject Code: CYQ004	**Subject Name:** Supramolecular Chemistry

Syllabus: Molecular Recognition: Definition and Characteristics of Intermolecular Interactions; van der Waals radius; Etter's Patterns of Intermolecular Interactions; Graph Theory; Host-Guest Assemblies; Hydrogen-Bonded Framework Ensembles; Metal-Organic and Framework (MOF) and Covalent Organic (COF) Structures; Preparation of HOFs, MOFs, and COFs - Co-crystals; Pharmaceutic co-crystals; Drugs and Polymorphs; Case Studies of Assemblies of 3,5-Dinitrobenzoic Acid and Its Derivatives, Cyanuric Acid, Itraconazole, and Aspirin.
Solids: Crystals & Amorphous Materials; Crystallization Process and Various methods; Kinetics and Thermodynamics of Solids; Phase diagrams; Defects in Solids; Photochemistry of Solids; Polymorphs and Polymorphism
Crystals and Microcrystals: Seven systems and 14 Bravais lattices; Space group; X-ray diffraction; Bragg's Equation; Structure Solution and Refinement; Important Crystallographic Parameters; Directions, Planes and Miller Indices; Thermal Techniques; Differential Scanning Calorimetry (DSC) and Thermal Gravimetric Analysis (TGA).

Text and Reference Books

1. Supramolecular Chemistry, J. W. Steed and J. L. Atwood, *John Wiley & Sons*, 2013
2. Angew. Chem. Int. Ed. 1995, *34*, 2311-2327.
3. Chem. Comm. 1996, 987-988; 997-998
4. X-ray Structure Determination, G. H. Stout and L. H. Jensen, *John Wiley & Sons*, 1989
5. Acta Crystallographica Section B, 1990, *46*, 256-262

Subject Code: CYQ005	**Subject Name:** Physical Methods in Chemistry

Syllabus: UV-Vis spectroscopy, Emission spectroscopy (Fluorescence and Phosphorescence), Infrared (IR) Spectroscopy, Mass Spectrometry, NMR Spectroscopy (including multinuclear NMR), Magnetic properties (d and f group elements), EPR spectroscopy (radicals and paramagnetic complexes), Mossbauer Spectroscopy (Fe and Sn compounds), Electrochemical Techniques (CV, DPV, Coulometry etc.)

Text and Reference Books

1. Drago R. S. Physical Methods in Inorganic Chemistry, Wiley Eastern Company.
2. Cotton F. A. and Wilkinson G. Advanced Inorganic Chemistry, Wiley-Eastern Company.
3. Lewis and Wilkins Modern Coordination Chemistry
4. Ebsworth E. A. V. Structural Methods in Inorganic Chemistry, ELBS Great Britain.

Subject Code: CYQ006	**Subject Name:** Coordination Chemistry

Syllabus: Structure and Bonding: Valence Bond Theory, Crystal Field Theory, Ligand Field Theory, Molecular Orbital Theory and their group theoretical treatment.

d-block (transition metal) chemistry: General considerations (colour paramagnetism, complex formation, variable oxidation states etc.), electronic spectra, and magnetic properties of coordination complexes of 3d, 4d and 5d transition metal ions. Thermodynamic stability, kinetic lability and kinetic inertness of Inorganic complexes and their reaction mechanisms, electron transfer process.

Lanthanide chemistry: spectral (absorption and emission) and magnetic properties, redox chemistry, analytical applications.

Text and Reference Books

1. Inorganic Chemistry, 4th Ed. By. Catherine E. Housecroft and Alan G. Sharpe
2. Inorganic Chemistry 5th Ed. By Shriver and Atkins
3. Advanced Inorganic Chemistry 6th Ed. By F. A. Cotton and G. Wilkinson

Subject Code: CYQ007	**Subject Name:** Bioinorganic Chemistry

Syllabus: Overview of bioinorganic chemistry: Properties of biological molecules. Physical methods in bioinorganic chemistry. Choice, uptake and assembly of metal containing units in biology. Transition metal storage, transport and biomineralization. Electron-transfer proteins. Bioinorganic chemistry of Fe, Cu, Mn, Mo. Metals in medicines.

Text and Reference Books

1. Lippard & Bartini Bioinorganic Chemistry.
2. Reedijk J. Bioinorganic Catalysis, Marcel Dekker.
3. Kaim W.; Schwederski B. and Klein A. Bioinorganic Chemistry: Inorganic elements in the chemistry of life, Wiley.

Subject Code: CYQ008	**Subject Name:** Nanochemistry and Technology

Syllabus: Introduction: Inorganic Materials Chemistry and Nanochemistry; Basics Nanomaterials Synthesis Methods: Bottom-up vs. Top-down Methods; Nanoclusters and Nanowires; Metal, Metal Oxide, semiconductor nanoparticles, quantum confinement, fluorescent properties, and Carbon Nanotubes. Inorganic Materials synthesis by Templating and Self-Assembly; 2-D Nanopatterns and Self-assembled Monolayers on Inorganic Substrates; Mesostructured and Mesoporous Materials; Inorganic-Organic and Inorganic-Polymer Nanocomposite Materials; Opals and Photonic Materials; Layer by layer self-assembly and core-shell Inorganic Nanomaterials; Biomimetics: Bioinspired Synthesis of Inorganic Nano biomaterials; Catalysis and Photocatalysis (Environmental remediation); Solar Cells and Nanoelectronics/ Nanophotonics Applications Studying and working

with matter on an ultra-small scale. Delivery of anti-cancer drugs. New ethical, health and safety or social issues

Text and Reference Books

1. Hornyak L. G.; Tibbals H. F.; Dutta J. and Moore J. J. *Introduction to Nanoscience and Nanotechnology*, CRC Press.
2. Arsenault A. and Ozin G. A. *Nanochemistry: A Chemical Approach to Nanomaterials*, RSC.
3. Klabunde K. J. *Nanoscale Materials in Chemistry*, Wiley Interscience.
4. Vollmer M. and Kreibig U. *Optical Properties of Metal Clusters*, Springer.

Subject Code: CYQ009	**Subject Name:** Quantum Chemistry

Syllabus: Old Quantum Mechanics: Failure of classical mechanics and the need for quantum mechanics. Black-body radiation, photoelectric effect, heat-capacity of solids, Bohr's atomic model, wave-particle duality, uncertainty principle.

New Quantum Mechanics: Wave mechanics and Schrodinger equation; postulates of quantum mechanics; time-dependent Schrodinger equation; origin of quantization in terms of exactly solvable models: box problem, simple harmonic oscillator, rigid rotor, and hydrogen atom, many-electron systems: spin, Pauli principle and Slater determinants; approximation methods: variation and perturbation theory.

Electronic structure theory: orbital approximation; molecular orbital and valence-bond methods; Huckel theory; self-consistent field methods and electron correlation.

Text and Reference Books

1. Quantum Chemistry by I. R. Levine
2. Quantum Chemistry by D. A. Macquarie
3. Molecular Quantum Mechanics by P.W. Atkins
4. Introduction to Quantum Mechanics with Applications to Chemistry by L. Pauling and E.B. Wilson Jr.
5. Introduction to quantum mechanics" by D. J. Griffiths.

Subject Code: CYQ010	**Subject Name:** Chemical Kinetics

Syllabus: Kinetics: Basic concepts: reaction order, molecularity, and rate laws; reaction mechanisms: time dependence of a reactants, intermediates, and products; multistep-reactions; Lindemann–Hinshelwood mechanism of unimolecular reactions; enzyme kinetics: catalysis and inhibition; diffusion-controlled reactions; surface reactions; experimental determination of rate constants; Arrhenius rate law and activation energy.

Dynamics: Kinetic theory of gases; collisional theory; potential energy surface; transition-state theory; RRKM theory; Marcus theory.

Text and Reference Books

1. Chemical Kinetics by K. J. Laidler
2. Chemical Kinetics and Dynamics by J.I. Steinfeld
3. J.S. Francesco, and W.L. Hase
4. Physical Chemistry" by P.W. Atkins, J. de Paula and J. Keeler.

Subject Code: CYQ011	**Subject Name:** Chemical Thermodynamics

Syllabus: Kinetics: Laws of thermodynamics: Thermodynamic equation of state and state variables; molecular interpretation of work, heat and internal energy; first law and energy conservation; expressions for mechanical work done in different thermodynamic processes: isochoric, isobaric,

adiabatic, quasi-static; heat capacity; enthalpy and thermochemistry: Hess's law, Kirchhoff's law; Joule experiment and internal pressure; Joule-Thomson experiment and Joule-Thomson coefficient; second law, entropy and energy dissipation; the concepts of spontaneity and thermodynamic reversibility; thermodynamic principles behind heat engine, heat pump and refrigerator; Clausius inequality; spontaneity of a process in terms of entropy, Gibbs energy and Helmholtz energy; free energy and maximum available work; Maxwell relations; thermodynamic equations of state; Gibbs-Helmholtz equation; third law; introduction to statistical thermodynamics: Boltzmann distribution, partition function and concepts of statistical ensembles.

Equilibrium: Phase equilibrium: phase diagrams, Clausius and Clausius-Clapeyron equations, phase rule; open systems: partial molar quantities, chemical potential, Gibbs-Duhem equation, thermodynamics of mixing and solutions: activity and fugacity, colligative properties; chemical equilibrium: equilibrium constant and Gibbs energy of reaction, effect of pressure and temperature on equilibrium, Ellingham diagram, acid-based equilibria; equilibrium electrochemistry: electrochemical cells, thermodynamic origin of Nernst equation, reduction potential, electrochemical series, Latimer diagram.

Text and Reference Books

1. Heat and thermodynamics by M.W. Zemansky and R.H. Dittman
2. Physical Chemistry by P.W. Atkins, J. de Paula and J. Keeler
3. Physical Chemistry" G.W. Castellan; "Fundamentals of Statistical and Thermal Physics" by F. Reif.

Subject Code: CYQ012	**Subject Name:** Biochemistry

Syllabus: Structure and function of biomolecules: Amino acids, Carbohydrates, Lipids, Proteins and Nucleic acids.

Principles of biochemical interactions: pH, buffer, Van der Waals, electrostatic, hydrogen bonding, hydrophobic interaction, reaction kinetics, thermodynamics, colligative properties.

Principles of catalysis: Enzyme and enzyme kinetics and inhibition, enzyme regulation, mechanism of enzyme catalysis, isozymes, vitamins, and coenzymes.

Metabolism: Catabolism vs anabolism, generation and utilization of ATP, glycolysis, TCA cycle, pentose phosphate pathway, oxidative phosphorylation, gluconeogenesis, glycogen and fatty acid metabolism, metabolism of nucleic acids (DNA and RNA) and proteins, RNA processing and splicing, post translational modifications. DNA-Protein Interactions: Electro mobility shift assay, DNase I foot printing, methyl interference assay.

R-DNA Technology: Restriction enzyme, cohesive and blunt end ligation, Northern, Southern, Western blotting, restriction maps, DNA fingerprinting, cloning vectors and expression vectors, cloning methodologies (insertion of foreign DNA into host cells: transformation, transduction, conjugation, transfection), construction of cDNA libraries and screening methodologies, PCR, gene silencing techniques: introduction to siRNA and siRNA technology, micro-RNA, CRISPR, CRISPR/Cas9 technology.

Text and Reference Books

1. Lehninger Principles of Biochemistry, Nelson and Cox
2. Biochemistry by Berg, Tymoczko and Stryer
3. Biochemistry by Voet and Voet

Subject Code: CYQ013	**Subject Name:** Molecular Cell Biology

Syllabus: Cell: Concept of cell, tissue system, organ and whole organism. Brief overview of plant and animal cells.

Cell signalling: Hormones and their receptors, cell surface receptor, signalling through G-protein coupled receptors, signal transduction pathways, second messengers, regulation of signalling pathways.

Cellular communication: Regulation of hematopoiesis, general principles of cell communication, cell adhesion and roles of different adhesion molecules, gap junctions, extracellular matrix, integrins, neurotransmission and its regulation.

Implementation of genetic engineering: Recombinant DNA technology; some important implementation of genetic engineering: Cholera Toxin, *Bt* toxins, GM food, transgenic plants, and animals.

Immune system: Immune system. Active and passive immunity. Complement system. Antibody structure, function and diversity. T, B and macrophages. T and B cell activation. Major histocompatibilty complex. T cell receptor.

Clinical biology of diseases: Various types of chromosomal and gene mutation, mutagens and mutagenesis, biology of some human diseases (diabetes, cardiovascular disease, AIDS, cancer etc.)

Text and Reference Books

1. Molecular Cell Biology by Lodish *et al*
2. Gene IX by Benjamin Lewin
3. Molecular Biology of Cell by Alberts *et al*

Subject Code: CYQ014	**Subject Name:** Chemical Biology

Syllabus: Introduction to chemical biology and the origin of life; Introduction to receptors: Structure, function, and classification; Receptors in human body and their role in physiology and diseases. Synthesis of biomacromolecules in chemical biology; Structural forces in the biomacromolecules; Integrating molecular biology tools in cloning and expression; Directed evolution of protein function and expansion of genetic code; Electronic and vibrational spectroscopy in chemical biology; Structural information of biomacromolecule; Molecular recognition and binding in chemical biology; Bioconjugation and bioassays; Catalysis in chemical biology

Text and Reference Books

1. Essentials of Chemical Biology, Andrew Miller and Julian Tanner, Wiley
2. Expanding the genetic code of Escherichia coli, Science. 2001; 292(5516):498-500
3. G-protein Coupled Receptors: Structure, Signaling and Physiology, Sandra Siehler and Graeme Milligan, Cambridge university press

Subject Code: CYQ017	**Subject Name:** A Concise History of Chemistry, Medicine, and Life Sciences in Ancient India

Syllabus: Module 1: Chemistry in Ancient India: Introduction, Chemical Ideas in the Vedas, Some Noted Ancient Indian Chemists, Their Biography, and Scriptures: (i) Patanjali, Charaka, Susruta, Nagarjuna, Vagbhata (ii) Charaka Samhita, Susruta Samhita, Rasaratnasamuchchaya. Chemistry of the Following Metals and Their Compounds: Mercury, Gold, Silver, Zinc, and Iron. Knowledge of Gunpowder, Saltpetre, Chile Saltpetre (Nitrate Salts), Mineral Acids, and Gems.

Module 2: Chemical Processes and Techniques in Ancient India: Introduction, Technology of Coinage Metals and Their Alloys in Ancient India: Copper, Bronze, and Brass. Iron and Indian Megaliths. Dyes and Pigments. Pottery. Tradition of Cosmetics and Perfumery, and Pyrotechnics.
Module 3: Life Sciences in Ancient India: Introduction, The Concept of Human Body. Surgery in Ancient India. Salakyatantra: Diseases of Supra-clavicular Parts. Rejuvenation and Virilization. Plant Science, Animal Science and Tradition. The Rigvedic Soma Plant and Somrasa. Yoga: Total Health.
Module 4: Medicines and Medicinal Practices in Ancient Indian: Introduction, Vedic Medicines. Fundamental Ideas of Ayurveda: Panchakarma, Doshas, Prakriti, Dhatus, Agni, Ama. Rasasastra Unravelled: Few Examples of Plant and Mineral/Metal Based Medicines Including Bhasmas. Unani Medicines, Hakims, Siddha Medicines, Folk and Tribal Medicines. A Science Initiative In Ayurveda (ASIIA) in 21st Century.

Text and Reference Books

1. Ray, A. P. C. History of Hindu Chemistry (Vol-1, 2), Bengal Chemical and Pharmaceutical Works, 1902
2. Subharayappa, B. V. (1999) History of Science, Philosophy and Culture in Indian Civilization; Chemistry and Chemical Techniques in India, PHISPC, 1999.
3. Subharayappa, B. V. History of Science, Philosophy and Culture in Indian Civilization; Medicine and Life Sciences in India, PHISPC, 1999.
4. Valiathan, M. S. The Legacy of Charaka, Orient Longman, 2003.
5. Valiathan, M. S. The Legacy of Susruta, Orient Longman, 2007.
6. Valiathan, M. S. An Introduction to Ayurveda, University Press, 2013.
7. Valiathan, M. S. Ayurvedic Inheritance, Manipal University Press, 2017.
8. Reddy, K. J.; Bahadur, B.; Bhadraiah, B.; Rao, M. L. N Advances in Medicinal Plants, Universities Press, 2007.
9. Kutumbiah, P. Ancient Indian Medicine, Orient BlackSwan, 1962.
10. Dahanukar S.; Urmila, T. Ayurveda Unravelled, National Book Trust, 1996
11. Courses/chapters available in NPTEL and Web: Ayurvedic Inheritance of India, IIT Madras- Dr M. S.Valiathan https://nptel.ac.in/courses/121106003
12. History of Science and Technology in India by B B Satapathy https://margheritacollege.in/admin_portal/all_mrgclg_files/department_studymat/History%20of%20science%20and%20technology%20in%20India9577.pdf