Birla Institute of Technology & Science, Pilani
Pilani Campus

Admission Brochure for PhD Admission Test: First Semester 2018-19

INDEX

Programmes offered

Applications are invited for admission to PhD programme at Pilani, Goa and Hyderabad campuses under 'Full Time' and 'Part Time' scheme in following Departments during First Semester 2018-19

Departments	BITS Pilani campus at					
	Pilani		Goa		Hyderabad	
	Full Time	Part Time	Full Time	Part Time	Full Time	Part Time
Biological Sciences	Yes	No	Yes	Yes	Yes	No
Chemical Engg.	Yes	Yes	Yes	Yes	Yes	No
Chemistry	Yes	No	Yes	No	Yes	Yes
Civil	Yes	Yes	NA	NA	Yes	Yes
CSIS	Yes	No	Yes	Yes	Yes	No
EEE	Yes	Yes	Yes	Yes	Yes	Yes
Humanities & Social Sciences	Yes	Yes	Yes	Yes	Yes	Yes
Economics & Finance	Yes	Yes	Yes	Yes	Yes	Yes
Management	Yes	Yes	NA	NA	NA	Yes
Mathematics	Yes	No	Yes	Yes	Yes	Yes
Mechanical	Yes	Yes	Yes	Yes	Yes	No
Pharmacy	Yes	Yes	NA	NA	Yes	Yes
Physics	Yes	No	Yes	Yes	Yes	Yes

Yes- A department does intend to admit student under specific scheme
No/NA- A department does not intend to admit student under specific scheme

Candidates are requested to visit the web page of respective department, or contact HoD, for further details.

Eligibility Criteria for Admissions

Any Higher Degree such as M.E./M.Pharm./MBA/M.Phil of BITS or its equivalent with a minimum of 60% aggregate in the qualifying examination. Candidates with an M.Sc./B.E./B.Pharm or an equivalent degree with a minimum of 60% aggregate may also be considered for Ph.D. admission subject to their suitability and competence. For Ph.D. Programme in Humanities and Social Sciences, candidates with an M.A. and with minimum of 55% aggregate may also be considered. Shortlisted candidates will be called for a written test/interview for selections.

Full time students: Candidates are required to devote their full time towards Ph.D. Short listed candidates will be required to come to designated campuses at Pilani / Goa / Hyderabad, for test and/or interview.

Part time students: Preferably individuals working in organizations providing basic facilities and environment for research to be admitted under this scheme.

Assistantship: Rs 25,000 per month: Institute Research Assistantship for 1st Year Full time PhD students. Higher Assistantship is paid in subsequent years. Students selected in sponsored research projects, will get the stipend according to the rule of funding agency.

Selected candidates will be required to participate in teaching and other academic programme of the institute under the guidance of a mentor.

Some Important Dates

Last date for completed application form to reach admission office	**16/5/2018 (5.00 PM)**
Declaration of shortlist to candidates (through BITS website)	**2/6/2018**
Test / Interviews:	**20/7/ 2018**
Announcement of admission offers to PhD Programmes	**23/7/ 2018**
Admission of Selected students	**30/7/ 2018**
Freshmen Orientation Programme	**30-31, July 2018**
Registration	**8/8/ 2018**

TEST DETAILS

(I) Candidates shortlisted for Test in any of the following disciplines:
Biological Science/Chemistry/Mathematics/Physics will have to write two tests. Test-I will be common to all disciplines and Test-II will be discipline specific. The details of the tests are as follows:

Test-I question paper consists of **30** multiple-choice type questions pertaining to General Science, Quantitative Reasoning & Analysis and Research Aptitude. The candidate is required to answer all the questions in allotted 1 hr time. Each correct answer will awarded two marks. 0.5 marks will be deducted for every wrong answer.

Test-II will be subject-based and will consist of 70 multiple-choice type questions covering the prescribed syllabus as given below. The candidate is required to answer all the questions in allotted 2 hr time. Each correct answer will be awarded two marks. 0.5 marks will be deducted for every wrong answer.

(II) Candidates shortlisted for Test in any of the following disciplines:
Languages/Humanistic Studies/Economics will have to write two tests. Test-I will be common to all disciplines and Test-II will be discipline specific. The details of the tests are as follows:

Test-I will comprise of the following components:

1.	Reading Comprehension: 2 Passages (5Qs each=10 Qs)	20 mts
2.	Logical Reasoning	10 question	10 mts
3.	Analytical Reasoning	15 question	15 mts
4.	General Awareness	10 question	15 mts
		50 Qs.	60 mts

Test-II will be discipline specific (60 questions)

(III) Candidates shortlisted for Test in Pharmacy:
The Pharmacy test would be a 2 Hours test consisting of two parts. Part-A would be common to all and would consist of questions in general Pharmacy subjects and Part-B will be based on subject taken by students in their MPharm Degree Program.

(IV) Candidates appearing for interview for Ph.D. program in the Department of Management will be required to take a written case analysis (Duration: 1 hour)

(V) Candidates appearing for interview for Ph.D. program in the Department of CSIS with highest degree as BE will be required to take a 2 hours objective type written test.

(VI) Candidates appearing for interview for Ph.D. program in the Department of Chemical Engineering with highest degree as BE will be required to take a 2 hours objective type written test.

Based on the tests there may be shortlisting of candidates for Interview

All notices/shortlists will be put on admission website www.bitsadmission.com. Candidates are advised to check this website regularly. No written communication will be sent to candidates.

Syllabus for Test

Biological Sciences

Laws of inheritance and genetic interaction, Genetic mapping in Virus. Bacteria, & Eukaryotes, Gene expression in prokaryotes and eukaryotes, Control of gene expression in prokaryotes eukaryotes and Viruses., Population and evolutionary genetics **Reference books:** Principles of Genetics –Robert H. Tamarin, 7th edition, Tata McGraw –Hill,2002.
Molecular Technique:
Restriction endonuleases, Vectors and cloning, Blotting technique, PCR, Sequencing **Reference books:** Principles of Gene Manipulation- R.W.Old & S.B.Primrose, 7th Edition
Biological Chemistry:
Chemistry of Biomolecules, Enzymes, Vitamins & Coenzymes, Bioenergetics and biological oxidation, Metabolism of Biomolecules, Photosynthesis **Reference books:** Principle of Biochemistry-Lehninger, Macmillan Worth Publication, 3rd edition
Microbiology:
Fundamentals of Microbiology, A survey of the microbial world, Host-Microbe interaction, Microbes and Human disease, Environmental and applied microbiology **Reference books :** Microbiology-An introduction (8th edition)- Tartora,Funk & Cane-Pearson publishing house.
Ecology :
Abiotic factors, Ecosystem ecology and energy flow, Community ecology and population ecology, Regional Ecology (Terrestrial and Aquatic), Regional Ecology (Terrestrial and Aquatic) **Reference books :** Concepts of Ecology by E J Kormondy Fundamentals of ecology by E. P. Odum .
Plant Physiology :
Transport and translocation of water and solutes, Essential elements and their function, Plant development and PGRs, Ascent of sap and translocation in phloem, Movement in plants **Reference books:** Plant physiology, 3rd edition by Salisbury & Ross- CBS Publisher and Distributor.
Biophysics :
Chemical properties of basic unit of life, energy forces, bonds., Conformation of Biomolecules, Biological membranes and Biomechaniques, Physiochemical techniques to study biomolecules, X-ray crystallography, NMR, molecular modeling. **Reference books :** Biophysical chemistry by Cantor and Schimmel. Biophysics by Rodney Cotteril.
Developmental Biology :
Model systems- Vertebrates, Invertebrates and Plants, Axis and germ layers, The mesoderm and early nervous system, Morphogenesis and cell differentiation, Organogenesis, germ cells and sex. **Reference books:** Principles of Development –Lewis Wolpert-Oxford University Press, 2nd edition
Cell Biology:
Preview of cell, cellular membranous systems, Transport, Mitochondria, Chloroplast, energy transducing organelle, Golgi, Nucleus, Cytoskeletal network, Cell growth & proliferation, Cell Immunity **Reference books:** Cell and Molecular Biology-Philip Sheeler & Donald E. Bianchi. 3rd edition, John Wiley Publication.
Animal physiology:
Digestive and Respiratory system, Circulatory system, Excretory system, Nervous and Endocrine system, Body Immune system **Reference books :** Animal Physiology by Sherwood et al, 1st edition- Thomson Publication. Animal Physiology by Sherwood et al, 1st edition-Thomson Publication.
Laws of inheritance and genetic interaction, Genetic mapping in Virus. Bacteria, & Eukaryotes, Gene expression in prokaryotes and eukaryotes, Control of gene expression in prokaryotes eukaryotes and Viruses., Population and evolutionary genetics **Reference books:** Principles of Genetics –Robert H. Tamarin, 7th edition, Tata McGraw –Hill,2002.

Chemistry

Physical Chemistry:

Basic principles and applications of quantum mechanics, angular momentum, hydrogen atom, atomic structure, chemical bonding, variational and perturbational methods, pure rotational spectroscopy, vibrational spectroscopy, vibrational-rotational spectroscopy, Raman spectroscopy, electronic spectroscopy, nuclear magnetic resonance spectroscopy, electron spin resonance spectroscopy, mass spectroscopy, fluorescence spectroscopy

Concepts and laws of thermodynamics, entropy, free energy, calculation of changes in thermodynamic properties, partial molar properties, ideal and real gases, ideal and non-ideal solutions, electrolytic solutions, colligative properties, phase equilibria, chemical equilibria, electrochemistry and applications, kinetic theory of gases, statistical thermodynamics

Chemical kinetics, rate laws, order and molecularity, determination of reaction mechanism, Arrhenius equation, theory of reaction rates, concept of catalysts, elementary reactions, consecutive elementary reactions, unimolecular reactions, polymerization kinetics, photochemical processes, quantum yield, enzyme kinetics, thermodynamic and kinetic control, physisorption and chemisorption, molecular interactions, self-assembly and transport processes

Reference books:

1. Donald A. McQuarrie, 'Quantum Chemistry', University Science Books (First Indian Edition 2003, Viva Books Private Limited).
2. Ira N. Levine, 'Quantum Chemistry', Pearson Education Inc. (2000) (First Indian Reprint, 20033.
3. P.W. Atkins and R.S. Friedman, 'Molecular Quantum Mechanics', 3rd Ed. OUP (1997). [4th ed. Has come out].
4. F.L. Pillar, 'Elementary Quantum Chemistry', 2nd ed., McGraw Hill (1990).
5. John P. Lowe, 'Quantum Chemistry', 2nd ed., Pearson Education Inc.
6. Ira N. Levine, Physical Chemistry, Tata McGraw Hill, 2002, 5th edition
7. Donald A. McQuarrie & J. D. Simon, 'Molecular Thermodynamics', Viva Book Pvt Ltd., New Delhi, 2004
8. R. C Srivastava, S K Saha, A K Jain, 'Thermodynamics', 2004

Inorganic Chemistry:

VSEPR Model, VB Theory, Ionic Crystal Structure, Structure of Complex Solids, Electronegativity, Acid-Base Chemistry, Chemistry in Aqueous and Non-Aqueous Solvents, Periodicity, Chemistry of transition metals, Redox chemistry.

Character Table and its Applications in Infrared and Raman spectroscopy and in Bonding; Coordination Chemistry: Bonding - Valence Bond, Crystal Field, and Molecular Orbital theories; Complexes - Nomenclature, Isomerism, Coordination Numbers, Structure, Electronic Spectra, Magnetic Properties, Chelate Effect; Reactions - Nucleophilic Substitution Reactions, Kinetics, Mechanisms; Organometallic Chemistry: Structure and Reaction of Metal Carbonyls, Nitrosyls, Dinitrogens, Alkyls, Carbenes, Carbynes, Carbides, Alkenes, Alkynes, and Metallocenes; Catalysis by Organometallic Compounds; Stereochemically Non-Rigid Molecules.

Bio-inorganic chemistry; metalloenzymes; metalloproteins; role of alkali and alkaline earth metal ions, iron, copper, zinc, molybdenum etc. in life processes; Basic concepts in electronic, magnetic and photonic materials and nanomaterials.

Reference books:

1. Chemical Application of Group Theory, F. A. Cotton, 3rd edition, John Wiley and Sons, Inc. 2011.
2. J. A. Cowan, "Inorganic Biochemistry An Introduction", Wiley-VCH, 2nd edition
3. Inorganic Chemistry – Principles of Structure and Reactivity, Huheey, J. E.; Keiter, E. A.; Keiter, R. L.; Medhi O. K.; 4th Edition, Pearson.
4. Concise Inorganic Chemistry, Lee, J.D. 5th Edition,Wiley India Edition.
5. Inorganic Chemistry, Shriver, D.F.; Atkins, P.W.; Overton T. L., Rourke, J. P., Weller, M. T., Armstrong, F. A. 4th edition, Oxford.

Organic Chemistry:

Structure and Reactivity of Organic Compounds: IUPAC nomenclature of organic compounds, Reactive intermediates (carbocations, carbanions, free radicals, carbenes, benzynes and nitrenes), Aromaticity (Benzenoid and non-benzenoid compounds), Aliphatic & Aromatic Nucleophilic and Electrophilic Substitutions, Addition Reactions (carbon-carbon and carbon-hetero-multiple bonds) Elimination Reactions, Neighboring Group Participation

Chemistry of Organic Compounds: Chemistry of functional groups, Structure, property and reactions of five and six membered heterocyclic (O, N and S) compounds, Organometallic compounds in organic synthesis, Natural products (carbohydrates, alkaloids, terpenes, amino acids).

Stereochemistry of Organic Compounds: Stereochemistry (isomerism, chirality, origin of optical activity, stereochemistry of cyclic compounds, resolution), Selectivity (chemo-, regio-, and stereoselectivity), Conformations and configurational analysis of acyclic and cyclic compounds, Resolution and other asymmetric induction methods, Name reactions and rearrangements.

Retrosynthetic Analysis: Disconnection approaches, Protecting Groups, Umpolung of reactivity, Ring synthesis and synthesis of Heterocyclic compounds

Pericyclic Reactions and Photochemistry: Orbital symmetry, Electrocyclisation, Cycloaddition, Sigmatropic rearrangements and other related concerted reactions, Principles and applications of photochemical reactions in organic chemistry

Spectroscopy of Organic Compounds: Structural elucidation of organic compounds using UV, IR, NMR ($1H$ & $13C$), Mass Spectrometry

Reference books:

1. March Jerry, Advanced Organic Chemistry, John Wiley & Sons, 4th edition, 1992.
2. Morrison and Boyd, Organic Chemistry, Prentice & Hall, 6th edition, 1992.
3. William Kemp, "Organic Spectroscopy", Macmillan, 3rd ed. 1991.

4. J. Clayden, N. Greeves, S. Warren, P. Wothers, Organic Chemistry, Oxford University Press.
5. Raj K Bansal, heterocyclic Chemistry, fifth edition (TB), New Age International publishers.
6. I. L. Finar, Organic chemistry Vol. 2, 5th Ed.; Pearson
7. Stuart Warren, Designing Organic Syntheses: A Programmed Introduction to the Synthon Approach, John Wiley and sons Ltd., 1978.
8. W. Graham Solomons and Craig B. Fryhle, 'Organic Chemistry', 8th Edition, John Wiley & Sons, Inc. New York, 2004.
9. F. A. Carey, Organic Chemistry, 5th Edition, Tata McGraw-Hill Publications Company Ltd., 2003.
10. P. A. Bruice, Organic Chemistry, 3rd Edition, Reason Edution, Inc. 2001.

Analytical Chemistry:

Instrumental methods of analysis: Magnetic Resonance Spectroscopy (^1H NMR, ^{13}C NMR, EPR), IR Spectroscopy, Mass Spectrometry, Ultraviolet and visible spectroscopy, fluorescence spectroscopy, chromatography and other separation techniques, Structure Resolution by combination of techniques.

Chemical experimentation: Chemical Experimentation: Functional group identification and synthesis of organic compounds, Chromatography techniques (TLC & HPLC), Separation and qualitative analysis of mixture of organic Compounds.

Acid base titrations, Complexometric titrations, Study of kinetics of chemical reactions, Determination of partition function, Adsorption isotherm, Synthesis and characterization of nanomaterials

Reference books:

William Kemp, "Organic Spectroscopy", Macmillan, 3rd ed, 1991

Vogel's textbook of practical organic chemistry 5th edition

Economics

Principles of Economics :

Demand, Supply, Elasticity, Consumer Behavior, Analysis of Production and Cost Analysis, Markets, Basics of Macro economics, Economics of Public Goods

Reference books:

Lipsey R G & Chrystal K A Economics OUP, 10th ed. 2004

Fundamentals of Finance & Accounting:

Basics of Accounting, Financial Statements and Analysis, Introduction to Securities, markets and analysis, Banking System, RBI, Non-bank financial intermediaries, Markets for Future, Options & Derivatives; Foreign Exchange Markets

Reference books :

Horngren, Sundem, and Elliott, Introduction to Financial Accounting, Pearson Education India Ltd. 8th ed. 2004

Bhole L.M, Financial Institution & Market Structure: Growth & Innovation, Tata McGraw Hill, 4th ed. 2004**.**

Microeconomics :

Theory of Consumer Behaviour, Topics in Consumer Theory, Theory of Firm, Theory of Market Structure, General Equilibrium, Welfare Economics**,** Externalities, Common & Public Goods

Reference books

Henderson J M and Quandt R E , Microeconomic Theory : A Mathematical Approach , McGraw Hill 3rd ed. 1980.

Macroeconomics:

Macroeconomic System- Measurement, I-O System, Flow of Funds, Keynesian System – Demand, Money, Interest , Income, Output, Inflation& Unemployment, Money Supply, Consumption and Investment, Consumption and Investment

Reference books :

Froyen, Richard T Macroeconomics: Theories & Policies Pearson Education, 8th ed. 2005.

Econometrics :

Basics of Statistics, OLS, ,k-variable Linear Equation, General Linear Model, Violation of classical Assumptions, Heteroscedasticity, Autocorrelation, Multi co linearity, ARIMA Model, Time Series Analysis, Simultaneous Equation System

Reference books :

Johnston J and John Dinardo, Econometric Methods McGraw Hill International, 4th ed. 1997.

Money Banking & Financial Markets :

Money and its Functions, Money Markets, Financial Markets and Financial Institutions, Foreign Exchange Markets, International Monetary Financial System, Banking Business, Bank Management , Financial Derivatives, Money, prices, economic activity; IMF

Reference books :

Mishkin, Frederic S The Economics of Money, Banking and Financial Markets: A Global Perspective Addison Wesley, 7th ed. 2004.

Public Finance – Theory and Practice :

Scope of Public Finance, Allocation, Distribution & Public Choices, Equity in Distribution, Public Choice & Fiscal Policy, Public Expenditure – Structure, Growth & Evaluation**,** Public Revenue, Principles of Taxation, Role of Fiscal Policy in India, Budgeting in India

Reference books:

Musgrave, R.A and Musgrave, P.B Public Finance : Theory and Practice McGraw Hill Book Co. 1999.

Economics of Growth and Planning :
Economic Growth Models – Harrod-Domar, Neo-classical, Two sector Models, The Fel'dman Model of Economic Growth, Samuelson Model of Economic Growth, Kaldor's Model of Income, Population, Environment, Inequality and Development, Planning in India
Reference books :
Jones H.G.An Introduction to Modern Theories of Economic Growth, McGraw Hill, Kogakusha Ltd. 1976.,
Devraj Ray Development Economics OUP, Delhi 1998
International Trade and Balance of Payments:
International Economics, Trade Theories, International Trade – Comparative Advantage, Heckscher –Ohlin (H-O) Model, Modern Theories of International Trade, Tariffs, Quotas, FDI, BOP, GATT, WTO, International Monetary System
Reference books:
Salvatore.D. International Economics WSE 8th ed. 2004
Issues in Indian Economy:
India's Economic Growth & Development, Significant Aspects of Indian Economy – Agriculture, Infrastructure, Private & Public Sector, Industrial Growth, Import- Exports, Unemployment, Commercial Banking & Finance, Inflation& Income Growth, Money Supply, Monetary Control, India's Trade, External Aid, Public Debt
Reference books:
Agarwal.A.N, Indian Economy – Problems of Development & Planning
Wishwa Prakashan, A division of New Age International(P) Ltd.,2005

Mathematics

Algebra
Permutations, combinations, pigeon-hole principle, inclusion-exclusion principle, derangements. Fundamental theorem of arithmetic, divisibility in Z, congruences, Chinese Remainder Theorem, Euler ϕ-function, primitive roots. Groups, subgroups, normal subgroups, quotient groups, homomorphisms, cyclic groups, permutation groups, Cayley's theorem, class equation, Sylow's theorem. Rings, ideals, prime and maximal ideals, quotient rings, unique factorization domain, principal ideal domain, Euclidean domain. Polynomial rings and irreducibility criteria. Fields, finite fields, field extensions, Galois Theory.
Reference books: Topics in Algebra by I.N. Herstein, Vikas Publishing House Pvt Ltd.
Analysis
Elementary set theory, finite, countable and uncountable sets, real number system as a complete ordered field, Archimedean property, supremum, infimum. Sequences and series, convergence, limsup, liminf. Bolzano Weierstrass theorem, Heine Borel theorem. Continuity, uniform continuity, differentiability, mean value theorem. Sequences and series of functions, uniform convergence. Reimann sums and Reimann integral, improper integrals and Reimann Stieltjes integral. Monotonic functions, types of discontinuity, functions of bounded variation. Lebesgue measure, measurable sets, measurable functions, Riemann and Lebesgue integral and their properties. Differentiations, functions of bounded variations, L^p spaces, different modes of convergence, metric spaces, compactness, connectedness. Normed linear spaces, spaces of continuous functions as examples.
Reference books: Principle of Mathematical Analysis by W. Rudin, Mc-graw hill Publishers. Measure Theory and Integration by G. D. Barra, Willey Eastern.
Topology
Topological spaces; special topologies, subspaces, product spaces and quotient spaces, continuity and homeomorphisms, connectedness and compactness, fundamental groups of surfaces.
Reference books: Topology by J.R. Munkres, Pearson Education publication.
Introduction to Topology and Modern Analysis by G.F. Simmons, Mc-graw hill Publishers.
Ordinary Differential Equations (ODEs)
Existence and uniqueness of solutions of initial value problems for first order ODEs, singular solutions of first order ODEs, system of first order ODEs. General theory of homogeneous and non-homogeneous linear ODEs, variation of parameters, Strum-Liouville boundary value problems, Green's function.
Reference books: Differential Equations by G.F. Simmons.
Elementary Differential Equations and Boundary Value Problems, 8th Edition, with ODE Architect CD by G. Krantz, Wiley.
Partial Differential Equations (PDEs)
Lagrange and Charpit's methods for solving first order PDEs, Cauchy problem for first order PDEs. Classification of second order PDEs, general solution of higher order PDEs with constant coefficients, method of separation of variables for Laplace, Heat and Wave equations.
Reference books: Elements of Partial Differential Equations by I.N. Sneddon, Mc-graw hill Publisher.
Linear Algebra
Vector spaces, subspaces, linear dependence, basis, dimension, algebra of linear transformations. Algebra of

matrices, rank and determinant of matrices, linear equations. Eigenvalues and eigenvectors, Cayley-Hamilton's theorem. Matrix representation of linear transformations. Change of basis, canonical forms, diagonal forms, triangular forms, Jordan forms. Inner product spaces, orthonormal basis. Quadratic forms, reduction and classification of quadratic forms.

Reference books: Linear Algebra by K. Hoffmenn and R. Kunze, Prentice hall of India Pvt Ltd.

Linear algebra and matrix theory by J. Gilbert and L. Gilbert, Brooks Cole.

Introduction to linear algebra by G. Strang Wellesley Cabridge Press.

Complex Analysis

Algebra of complex numbers, the complex plane, polynomials, power series, transcendental functions such as exponential, trigonometric and hyperbolic functions. Analytic functions, Cauchy-Riemann equations. Contour integral, Cauchy's theorem, Cauchy's integral formula, Liouville's theorem, maximum modulus principle, Schwarz lemma, open mapping theorem. Taylor's series, Laurent's series, calculus of residues. Conformal mappings, Mobius transformations.

Reference books: Complex Variables and Applications by James Brown, R. V Churchill.

Numerical Analysis

Computer arithmetic and errors, numerical solutions of algebraic equations, method of iteration and Newton-Raphson method, rate of convergence. Solution of systems of linear algebraic equations by using Gauss elimination and Gauss-Seidel methods. Finite differences, Lagrange, Hermite and spline interpolation, numerical differentiation and integration. Numerical solution of ODEs using Picard, Euler, modified Euler and Runge-Kutta methods.

Reference books: Applied Numerical Analysis by Gerald and Wheatley 6/E, Pearson Education.

Functional Analysis

Normed linear spaces, Riesz lemma, Banach spaces, normed linear spaces, continuous linear transformations on normed linear spaces, inner product spaces, Hilbert spaces, orthogonal sets, direct sum, Bessel's inequality, Riesz representation theorem, uniform boundedness principle, open mapping theorem, closed graph theorem.

Reference books: Introduction to Functional Analysis by B.V. Limaye, New Age international Publishers 2000.

Introductory Functional Analysis with Applications by Erwin Kreyszig.

Probability

Sample space, discrete probability, independent events, Bayes' theorem. Random variables and distribution functions (univariate and multivariate); expectation and moments. Independent random variables, marginal and conditional distributions. Characteristic functions. Probability inequalities (Tchebycheff, Markov, Jensen). Modes of convergence, weak and strong laws of large numbers, central limit theorems (i.i.d. case).

Reference books: Introduction to Probability and Statistics: Principles and Applications for Engineering and the Computing Sciences by J. Susan Milton.

Schaum's Outline of Probability and Statistics by Murray R Spiegel, John J. Schiller, R. Alu Srinivasan.

Optimization

Modeling with linear programming, general L.P. solution, The simplex method, duality and post optimal analysis, transportation model and its variants, goal programming and integer linear programming, non linear programming algorithms.

Reference books: Operations Research: An Introduction by Hamdy A Taha 8/E, Prentice Hall India/Pearson Education.

Operations Research

Queuing systems: Poisson queuing systems, Reliability: reliability and hazard rate function of series and parallel systems, inventory systems: single item inventory models, simulation and game theory, network models and deterministic dynamic programming.

Reference books: Operations Research: An Introduction by Hamdy A Taha.

Advanced Calculus

Functions of several variables, directional derivative, partial derivative, and derivative as a linear transformation, inverse and implicit function theorems.

Reference books: Thomas's Calculus (11th Edition) by George B. Thomas, Maurice D. Weir, Joel Hass and Frank R. Giordano, Pearson Publication.

Physics

Modern Physics

Special Theory of Relativity, Particle-like Properties of Waves, Wave-like Properties of Particles, Heisenberg Uncertainty Relation, Bohr's Model of Hydrogen-like Atoms, Schrodinger Equation, Particle in One-dimensional Potential, Particle in One-dimensional Potential, Many Electrons Atoms, Physics of Molecules, Nuclear Transformations

Reference books :
R. Eisberg & R. Resnick, Quantum Physics of Atoms, Molecules & Solids, WSE, 2nd ed., 1985
Arthur Beiser, Concepts of Modern Physics, Tata McGraw-Hill, 6th ed., 2005
Thermodynamics & Properties of Matter
Thermometry, Thermal Expansion, Heat, Work and the First Law of Thermodynamics, Second Law of Thermodynamics, Heat Engines and Entropy, Kinetic Theory, Phase Transformations, General Properties of Matter **Reference books :** Zemansky & Dittman, Heat & Thermodynamics, 6th ed., McGraw-Hill, 1981
Classical Mechanics
Constraints, Generalized Coordinates, De-Alembert's principle, Lagranges Equations of Motion, Two-body Central force motion, Rigid Body Kinematics, Rigid Body Dynamics, Hamilton's Equations of Motion **Reference books :** H Goldstein, Classical Mechanics, Pearson Education, 3rd ed., 2002
Electromagnetic Theory
Electrostatics in Free Space, Electrostatics in Matter, Magnetostatics in Free Space, Magnetostatics in Matter, Faraday's Law of Electromagnetic Induction, Maxwell's Equations, Conservation Laws, Electromagnetic Waves, Electromagnetic Potentials, Fields and Radiations **Reference books :** D. J. Griffiths, Introduction to Electrodynamics, Pearson Education, 3rd ed., 1999
Quantum Mechanics
Schrodinger Equation, Eigenvalues, Eigenfunctions, Eigenfunction Expansion, Dirac Notation, Operator Methods, Harmonic Oscillator, Angular Momentum, Central Force Problem, The Hydrogen Atom, Spin, Identical Particles, Time Independent Perturbation Theory **Reference books :** Richard L. Liboff, Introductory Quantum Mechanics, Pearson Education, 4th ed., 2003 Stephen Gisiorowicz, Quantum Physics, John Wiley & Sons Inc., 3rd ed., 2003
Methods of Mathematical Physics
Vector Analysis, Curvilinear Coordinates, Matrices and Vector Spaces, Functions of Complex Variables, Ordinary Differential Equations, Sturm-Lioville Theory and Special Functions, Elements of Partial Differential Equations **Reference books :** Mathew Jon & R. Walker, Mathematical Methods of Physics, Pearson Education, 2nd ed., 1970 Arfken & Weber, Mathematical Methods for Physicists, Academic Press, 6th ed., 2005
Statistical Physics
Elements of Probability Theory, Elementary Kinetic Theory, Microcanonical, Canonical & Grand Canonical Ensembles and Their Applications, Quantum Statistics of Ideal Bose Gases, Quantum Statistics of Ideal Fermi Gases **Reference books :** Pathria R K, Statistical Mechanics, Elsevier, 2nd ed., 1996
Solid State Physics
X-ray Diffraction and Crystal Structure, Lattice Dynamics, Free Electron Theory of Metal, Electron in Periodic potential, Energy Bands, Semiconductors, Superconductivity **Reference books:** Kittel C., Introduction to Solid State Physics, WSE, 7th ed., 1995
Optics & Spectroscopy
Geometrical Optics, Interference, Diffraction, Polarization, Crystal Optics & Lasers, Atomic & Molecular Spectroscopy **Reference books:** Ghatak, A K, Optics, Tata McGraw-Hill, 3rd ed., 2005 Banwell C N, Fundamentals of Molecular Spectroscopy, Tata Mc-Graw-Hill, 4th ed.,1994
Nuclear & Particle Physics
Nuclear Properties and Nuclear Models, Fission & Fusion, The Quark Model, Elementary Particles, their Classification and Interactions, Particle Accelerators, Conservation Laws of Elementary Particles and Fundamental Interactions **Reference books :** Krane K, Introductory Nuclear Physics, John Wiley & Sons, 1st ed., 1988 Griffiths, D J, Introduction to Elementary Particles, WIE, 1st ed., 1987

Computer Science

Spiritual Intelligence
Reference books:
Zohar and Marshall, Spiritual Intelligence The Ultimate Intelligence, Bloomsbury, 2001. Schuller, Peter A. ,Spiritual Intelligence, Author House, 2003.
Political Science
Reference books:
Robert E. Goodin, Philip Pettit and Thomas Pogge (Eds.) 2007. A Companion to Contemporary Political Philosophy (2nd edition), Oxford: Blackwell. Goodwin, Barbara (2014) Using Political Ideas (6th Edition). New York: John Wiley Bhargava, Rajeev & Acharya, Ashok (2008) Political Theory; An Introduction (2nd Edition). Pearson Education India
Development Economics
Reference books:
Misra, S. K. and Puri, V. K. (2005), Development and Planning: Theory and Practices (13th Revised Edition), Himalaya Publishing House, Bombay Todaro, M. (2000) Economic Development.7th Ed. Delhi: Pearson Education. 338.9 TOD.SMI Thirlwall, A. P. (2006) Growth and Development with Special Reference to Developing Economies. 8th ed. Hampshire: Palgrave Macmillan. 338.90091724 THI/Gro Meier, G. M. & Rauch, J. E. (2000) Leading Issues in Economic Development.7thed. New York: OUP. 338.9 MEI.RAU Ray, D. (1998) Economic Development. New Delhi: OUP 338.9 RAY/DEV
Introduction to Development Studies
Reference books:
Rapley, John. 2009. Understanding Development: Theory and Practice in the Third World (3rdEdition).Viva Books
International Relations
Reference books:
John Baylis;(2001). The Globalization of World Politics: An Introduction to International Relation; Oxford University Press; 2nd Edition. http://bit.ly/XhmCPF https://yfadukypyz.files.wordpress.com/.../the-globalization-of-world-pol... https://peaceandconflictstudiesblog.files.wordpress.com/.../the-globalizati... Students are also expected to be familiar with NCERT's Contemporary World Politics - http://www.ncert.nic.in/ncerts/textbook/textbook.htm?leps1=0-9
Ecocriticism
Garrard, Greg. Ecocriticism. London: Routledge, 2012. Print. Cheryll Glotfelty and Harold Fromm. Eds. The Ecocriticism Reader: Landmarks in Literary Ecology. Athens :University of Georgia Press, 1996. Print.

The Computer Science test will be based on the following subject:

1. Data structures and Algorithms
2. Operating Systems
3. Computer Organization & Architecture
4. Database systems
5. Software engineering

Chemical Engineering

Chemical Process Calculations
Units and Dimensions, The Chemical Equation and Stoichiometry**,** Material Balances, Energy Balances, Properties of Gases, Vapors, Liquids and Solids, Phase Equilibria, Combustion Calculation, Unsteady-State Material and Energy Balances. **Reference books:** Himmelblau, D. M. "Basic principles & calculations in chemical Engg", PHI, 6th ed., 1997.

Felder, R. M. & R. W. Rousseau, "Elementary Principles of Chemical Processes", John Wiley & Sons, Inc., 3rd ed., 2000.

Fluid Flow Operations

Fundamental Concepts and Fluid Statics, Integral and Differential Analyses for Fluid Motion, Internal and External Fluid Flow and Flow through Packed Bed, Dimensional Analysis and Fluid Machinery, Agitation and Introduction to Compressible Flow.

Reference books:

Fox, R. W. and A. T. McDonalds, Introduction to Fluid Mechanics (5th edition) John Wiley and Sons Inc., 2001.

McCabe, W. L., J. C. Smith and P. Harriott Unit Operations of Chemical Engineering (7th edition), McGraw Hill Inc., 2005.

Chemical Engineering Thermodynamics

First & Second Laws, PVT behavior & Heat Effects, Properties of pure fluids and thermodynamics of flow processes, Solution thermodynamics, VLE and chemical reaction equilibrium.

Reference books:

J. M.Smith, and Others,"Introduction to Chemical Engineering Thermodynamics", MGHFSE, 6th ed., 2001

YVC Rao, "Chemical Engineering Thermodynamics", Universities Press, 1997.

KV Narayanan, "A Textbook of Chemical Engineering Thermodynamics". Prentice Hall of India, 2001.

Mass Transfer Operations

Molecular diffusion and mass transfer coefficients, Interphase mass transfer, Gas absorption, Distillation, Liquid extraction and leaching.

Reference books:

Treybal, R.E., "Mass Transfer Operations," 3rd Ed., McGraw-Hill Book Company, Singapore, 1980.

Foust, A. S., Wenzel, L.A., Clump, C.W., Anderson, L.B., "Principles of Unit   Operations," 2nd Ed., John Wiley and Sons, New York, 1980.

Heat Transfer Operations

Steady and Unsteady state heat conduction, Natural & Forced convection, Radiation, Condensation, boiling and evaporation, Heat Exchangers.

Reference books:

Holman, J. P., "Heat Transfer (9th Ed.)", McGraw-Hill, 2002.

Frank P. Incropera, David P. DeWitt, "Fundamental of Heat & Mass Transfer (6th Ed.)", John Wiley & Sons, 2006.

D. Q. Kern, "Process Heat Transfer", Tata McGraw Hill.

McCabe & Smith, "Unit Operations of Chemical Engineering (7th ed)", McGraw-Hill, 2004.

Selected Chemical Engineering Operations

Properties and Handling of Particulate Solids, Mechanical Separations, Adsorption and Fixed-Bed Separations, Drying of Solids, Membrane Separation Processes and Crystallization.

Reference books:

McCabe W. L., and Smith J. M., & Harriott P., *Unit Operations of Chemical Engineering*, 7th Ed., McGraw-Hill International Edition, 2006.

Chemical Engineering (Volumes 1-6), Coulson J. M., Richardson J. F. & others, Pergamon Press, London, 1978 & 1997.

Kinetics & Reactor Design

Mole balances and reactor sizing, Rate laws and stoichiometry, Isothermal reactor design for single and multiple reactions, Analysis of laboratory reactor data, and reaction mechanisms for nonelementary reactions, Non isothermal reactor design for single and multiple reactions, Heterogeneous reactors, Data analysis & design, Non Ideal reactors.

Reference books:

H. Scott Fogler "Elements of   Chemical Reaction Engineering", PHI, 3rd Ed, 2002.

O. Levenspiel, "Chemical Reaction Engineering", John Wiley, 3rd Ed., 1999.

J.M. Smith, "Chemical Engineering Kinetics", McGraw Hill, 3rd Ed., 1981.

Chemical Process Technology

Process synthesis concepts for flow sheet generation; species allocation; separation task sequence and task integration, Technologies related to Inorganic Chemical Industries, Technologies related to Natural Product Industries, Technologies related to synthetic organic chemical industries, Technologies related to Polymerization industries.

Reference books:

Rao, G. and Sittig M., "Dryden's outlines of chemical technology for 21st century", East West Press, 1997.

Austin, G T, "Shreve's chemical process industries", McGraw Hill, 1984.

Process Design Decisions

Engineering Economics; Economic Decision Making, Input Information and Batch versus Continuous; Input-Output Structure, Recycle Structure; Separation System, Heat Exchanger Networks (Energy Integration), Cost Diagrams; Preliminary Process Optimization; Process Retrofits.

Reference books:

James M. Douglas. Conceptual Design of Chemical Processes. McGraw-Hill International Editions (Chemical Engineering Series), Mc Graw Hill Book Company, New York, 1988.

Max S. Peters, Klaus D. Timmerhaus, Ronald E. West, Max Peters. Plant Design and Economics for Chemical Engineers. 5th Edition, Mc Graw Hill, New York, 2003.

Process Control

Dynamic modeling and simulation of momentum, energy, mass transfer and reacting systems, Analysis of the dynamic behavior of chemical processes, Analysis and design of simple feedback and advanced control systems, Design of control systems with multiple input and multiple output, Digital sampling, filtering and control.

Reference books:
Stephanopoulos, G., "Chemical Process Control: An Introduction to Theory and Practice," Prentice-Hall, Englewood Cliffs, N.J., 1984
Seborg, D.E., Edgar, T.F. and Mellichamp, D.A., "Process Dynamics and Control," 2nd Ed., John Wiley and Sons, 2004.
Coughnowr, D. R., and Koppel, I. B., "Process Systems Analysis and Control," 2nd Ed., McGraw-Hill, New York, 1991.

Humanities & Social Sciences:

Media Studies :
Cinematic Art, Cinematic Adaptation, Understanding News, Current Affairs, Mass communication, Advertising, Media Writing, Content Design, Short Film Making **Reference books:** Hartley, J. Understanding News. London: Routledge. 1991 2nd Ed The Oxford Guide to Film Studies. Richard Dyer et al. A&C Black Publishers Ltd. London, 2008 Belch, George E. and Michael A. Belch. 1998. Advertising and Promotion. Sixth Ed. New Delhi: Tata McGraw-Hill.
Communication:
Business Communication, Conflict Management, Technical Communication **Reference books:** Lesikar and Flately. 2005. Basic Business Communication. New Delhi: Tata McGraw Hill 10th ed. The Dynamics of Conflict Resolution, San Francisco: Wiley Company, 2000
Phonetics, Language & Literature:
English Language Teaching, English Usage, Phonetics and Language, English Literature: Elizabethans and Augustan, Pre-romantics and Romantics, Victorian Literature, Twentieth Century Literature: Poetry and Drama, Twentieth Century Literature: Prose and Fiction,Indian Writing in English, Applied Linguistics, American Literature, Women's Writing, Postcolonial Literature **Reference books:** The Oxford Companion To English Literature. A Critical History of English Literature (Vol – I & II) by David Daiches. Studying English Literature (A Practical Guide) by Tory Young. Murphy, R. (2012). English grammar in use. Cambridge: Cambridge University Press. Richards, J. C., & Rodgers, T. S. (2001). Approaches and methods in language teaching. Cambridge: Cambridge University Press. Nunan, David, & Newbury House Teacher Development. (1999). Second language teaching & learning. Boston, Mass: Heinle&Heinle.
Music:
Logic and science working behind music, Schools of musical training, Musical forms and styles **Reference book:** SangeetRatnakar by Sharangdev
Other HSS areas :
Test can also be conducted in these subjects depending upon the applications: Sociology, Public Policy, Gender Studies, History, Psychology, Philosophy, Political Science, Professional Ethics, Education
Digital Humanities:
Reference books: "A Companion to Digital Humanities". Schreibman, S., Siemens, R., Unsworth, J. (Eds). Blackwell Companions to Literature and Culture. Paperback Edition, 2007. (Available freely online at http://www.digitalhumanities.org/companion/) "A Companion to Digital Literary Studies". Schreibman, S., and Siemens, R., (Eds). Blackwell Companions to Literature and Culture. 2008. (Available freely online at http://www.digitalhumanities.org/companionDLS/)
Philosophy
Reference books: Soccio, Douglas J. 2001. Archetypes of Wisdom: An Introduction to Philosophy. Wad sworth. Moore, Brroke Noel and Burder, Kenneth. 2005. Philosophy: The Power of Idea. Tata McGraw-Hill. The Essentials of Indian Philosophy, M. Hiriyanna, 2015, Motilal Banarsidass Publishers
General Psychology
Reference books: Robert A Baron, Psychology, Prentice Hall of India, 2005

Cognitive Psychology	
Reference books: Levitin, D. J. 2002. Foundaitons of Cognitive Psychology. The MIT Press. Martline, M.W. 2013. Cognitive Psychology, John Wiliey & Sons.	
Educational Psychology	
Reference books: Educational Psychology, 2nd edtition, The Saylor Foundation (https://www.saylor.org/site/wp-content/uploads/2012/06/Educational-Psychology.pdf)	
Education	
Reference books: Contemporary Issues in Higher Education, 2nd Edition, Richard Fossey, Kerry Brian Melear, and Joseph C. Beckham, eds. (2011) Issues and Challenges on Higher Education, (Eds. Doris Phillips Singh and Naveen Sameul Singh), Words Worth, 2012.	
Organizational Behavior	
Reference books: Robins, Stephen; Judge, Thimonthy A; and Sanghi, Sooma. 2010. Essentials of Organizational Behavior. Pearson Education India	
Spiritual Intelligence	
Reference books: Zohar and Marshall, Spiritual Intelligence The Ultimate Intelligence, Bloomsbury, 2001. Schuller, Peter A. ,Spiritual Intelligence, Author House, 2003.	
Political Science	
Reference books: Robert E. Goodin, Philip Pettit and Thomas Pogge (Eds.) 2007. A Companion to Contemporary Political Philosophy (2nd edition), Oxford: Blackwell. Goodwin, Barbara (2014) Using Political Ideas (6th Edition). New York: John Wiley Bhargava, Rajeev & Acharya, Ashok (2008) Political Theory; An Introduction (2nd Edition). Pearson Education India	
Development Economics	
Reference books: Misra, S. K. and Puri, V. K. (2005), Development and Planning: Theory and Practices (13th Revised Edition), Himalaya Publishing House, Bombay Todaro, M. (2000) Economic Development.7th Ed. Delhi: Pearson Education. 338.9 TOD.SMI Thirlwall, A. P. (2006) Growth and Development with Special Reference to Developing Economies. 8th ed. Hampshire: Palgrave Macmillan. 338.90091724 THI/Gro Meier, G. M. & Rauch, J. E. (2000) Leading Issues in Economic Development.7thed. New York: OUP. 338.9 MEI.RAU Ray, D. (1998) Economic Development. New Delhi: OUP 338.9 RAY/DEV	
Introduction to Development Studies	
Reference books: Rapley, John. 2009. Understanding Development: Theory and Practice in the Third World (3rdEdition).Viva Books	
International Relations	
Reference books: John Baylis;(2001). The Globalization of World Politics: An Introduction to International Relation; Oxford University Press; 2nd Edition. http://bit.ly/XhmCPF https://yfadukypyz.files.wordpress.com/.../the-globalization-of-world-pol... https://peaceandconflictstudiesblog.files.wordpress.com/.../the-globalizati... Students are also expected to be familiar with NCERT's Contemporary World Politics - http://www.ncert.nic.in/ncerts/textbook/textbook.htm?leps1=0-9	
Ecocriticism	
Garrard, Greg. Ecocriticism. London: Routledge, 2012. Print. Cheryll Glotfelty and Harold Fromm. Eds. The Ecocriticism Reader: Landmarks in Literary Ecology. Athens :University of Georgia Press, 1996. Print.	