Admission Brochure for PhD Admission Test: First Semester 2015-16

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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 2015-16

<table>
<thead>
<tr>
<th>Departments</th>
<th>BITS Pilani campus at</th>
<th></th>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pilani</td>
<td>Goa</td>
<td>Hyderabad</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Full Time</td>
<td>Part Time</td>
<td>Full Time</td>
<td>Part Time</td>
<td>Full Time</td>
</tr>
<tr>
<td>Biological Sciences</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Chemical Engg.</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Chemistry</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Civil Engg.</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Computer Science &amp; Information Systems</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Electrical &amp; Electronics Engg.</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Humanities &amp; Social Sciences</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Economics &amp; Finance</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Management</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Mathematics</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Mechanical Engg.</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Pharmacy</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Physics</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
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</table>
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. Selected candidates will be entitled to 90% tuition fee waiver. Short listed candidates will be required to come to Pilani / Goa / Hyderabad campuses for test and/or interview. The seats under full time schemes are limited so preference will be given to candidates working in ongoing sponsored projects in the Institute, and the CSIR/UGC-NET qualified candidates.

**Part time students:** Candidates working in organizations situated in close vicinity of campuses of BITS Pilani will be admitted under this scheme. They may be considered for 80% waiver in tuition fee.

**Assistantship (Fee Waiver and Stipend):** Those admitted to full time PhD programme will be considered for Project/Research Assistantships to the tune of Rs. 13,200/- to Rs. 18,200/- per month or more in addition to tuition fee waiver (as above). Selected candidates will be required to participate in teaching and other developmental programme of the institute under the guidance of a mentor.
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 be 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](http://www.bitsadmission.com). Candidates are advised to check this website regularly. No written communication will be sent to candidates.
Some Important Dates

Last date for completed application form to reach admission office: **20\textsuperscript{th} May 2015 (5.00 PM)**

Declaration of shortlist to candidates: (through BITS website): **2\textsuperscript{nd} June 2015**

Test / Interviews: **20\textsuperscript{th} July 2015**

Announcement of admission offers to PhD Programmes: **23\textsuperscript{rd} July 2015**

Admission of Selected students: **29\textsuperscript{th} July 2015**

Freshmen Orientation Programme: **30\textsuperscript{th}-31\textsuperscript{st} July 2015**

Registration for courses: **1\textsuperscript{st} August 2015**
Syllabus for Test

Biological Sciences

<table>
<thead>
<tr>
<th>Genetics</th>
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<tbody>
<tr>
<td>Laws of inheritance and genetic interaction, Genetic mapping in Virus, Bacteria, &amp; Eukaryotes, Gene expression in prokaryotes and eukaryotes, Control of gene expression in prokaryotes eukaryotes and Viruses., Population and evolutionary genetics</td>
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</tbody>
</table>

**Reference books:**

<table>
<thead>
<tr>
<th>Molecular Technique</th>
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<tbody>
<tr>
<td>Restriction endonuclases, Vectors and cloning, Blotting technique, PCR, Sequencing</td>
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</table>

**Reference books:**

<table>
<thead>
<tr>
<th>Biological Chemistry</th>
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<tbody>
<tr>
<td>Chemistry of Biomolecules, Enzymes, Vitamins &amp; Coenzymes, Bioenergetics and biological oxidation, Metabolism of Biomolecules, Photosynthesis</td>
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</table>

**Reference books:**

<table>
<thead>
<tr>
<th>Microbiology</th>
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<tr>
<td>Fundamentals of Microbiology, A survey of the microbial world, Host-Microbe interaction, Microbes and Human disease, Environmental and applied microbiology</td>
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</table>

**Reference books:**

<table>
<thead>
<tr>
<th>Ecology</th>
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<tbody>
<tr>
<td>Abiotic factors, Ecosystem ecology and energy flow, Community ecology and population ecology, Regional Ecology (Terrestrial and Aquatic), Regional Ecology (Terrestrial and Aquatic)</td>
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</tbody>
</table>

**Reference books:**
Concepts of Ecology by E J Kormondy
Fundamentals of ecology by E. P. Odum.

<table>
<thead>
<tr>
<th>Plant Physiology</th>
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<tbody>
<tr>
<td>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</td>
</tr>
</tbody>
</table>

**Reference books:**
Plant physiology, 3rd edition by Salisbury & Ross- CBS Publisher and Distributor.

<table>
<thead>
<tr>
<th>Biophysics</th>
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<tbody>
<tr>
<td>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.</td>
</tr>
</tbody>
</table>

**Reference books:**
Biophysical chemistry by Cantor and Schimmel.
Biophysics by Rodney Cotteril.

<table>
<thead>
<tr>
<th>Developmental Biology</th>
</tr>
</thead>
<tbody>
<tr>
<td>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.</td>
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</tbody>
</table>

**Reference books:**

<table>
<thead>
<tr>
<th>Cell Biology</th>
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</thead>
<tbody>
<tr>
<td>Preview of cell, cellular membranous systems, Transport, Mitochondria, Chloroplast, energy transducing organelle, Golgi, Nucleus, Cytoskeletal network, Cell growth &amp; proliferation, Cell Immunity</td>
</tr>
</tbody>
</table>

**Reference books:**

<table>
<thead>
<tr>
<th>Animal Physiology</th>
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</thead>
<tbody>
<tr>
<td>Digestive and Respiratory system, Circulatory system, Excretory system, Nervous and Endocrine system, Body Immune system</td>
</tr>
</tbody>
</table>

**Reference books:**
### Chemistry

#### Chemical Kinetics:

#### Chemical Thermodynamics:

#### Quantum Chemistry and Atomic and Molecular Structure:
- Mathematical and Physical Foundations of Quantum Chemistry. Simple potential problems in one, two and three dimension including particle in a box, harmonic oscillator, potential barrier, rigid rotator hydrogen atom, He-atom, effective nuclear charge, Slater orbitals, electron spin, Solution of Hartree-Fock equation for He-atom, self-consistent field, Two electron system, Slater determinants, Hartree-Fock method. Approximation methods, variation, perturbation theory angular momentum, Atomic structure, Molecular structure
- Reference books:

#### Structure and Reactivity of Organic Compounds:
- Aliphatic & Aromatic Nucleophilic Substitutions, Aromatic Electrophilic Substitution, Addition to carbon-carbon multiple and carbon-heteromultiple bonds, Eliminations, Orbital symmetry in organic reactions
- Reference books:

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

#### Bonding in inorganic compounds:
- Point Groups and Molecular Symmetry, Character Tables and applications of point group symmetry, Ionic bond; Polarization, Covalent bond; VB and MO theories, Coordination Compounds bonding and spectra
- Reference books:

#### Chemical experimentation:
- Acid base titrations, Complexometric titrations, Synthesis of organic compounds and functional group identification, Study of kinetics of chemical reactions, Determination of partition function, Adsorption isotherm, Synthesis and characterization of nanomaterials, Qualitative analysis of salts/mixture of salts
- Reference books:
  - Vogel’s textbook of practical organic chemistry 5th edition
  - Vogel’s textbook of quantitative inorganic analysis
  - Vogel’s qualitative inorganic analysis, 7th edition

#### Synthetic organic Chemistry:
- One Group C-X Disconnections, Two Group C-X Disconnections, One Group C-C Disconnections, Two Group C-C Disconnections, Ring Synthesis and Synthesis of Heterocyclic Compounds
- Reference books:
### Basic organic and inorganic chemistry:

- Stereochemistry (Isomerism, chirality, origin of optical activity, stereochemistry of cyclic compounds, resolution), Conformations (Rotation around sigma bonds, conformational analysis of butane, cyclohexane, and substituted cyclohexanes.), Name reactions (Diels Alder reaction; Friedel-Crafts(acylation and alkylation) reaction; Clemmensen reduction; Wittig reaction; Claisen condensation; Hofmann and Cope eliminations), Co-ordination chemistry, Chemistry of main group elements.

**Reference books:**

### Chemistry of Organic Compounds:

- Carboxylic acid and carboxylic acid derivatives, Chemistry of aliphatic and aromatic amines, Structure, property and reactions of five and six membered heterocyclic compounds containing O, N and S., Organometallic compounds in organic synthesis: Organolithium, Organomagnesium, Organozinc and Organocopper, Carbohydrates.

**Reference books:**

### Economics

#### Principles of Economics:


**Reference books:**

#### Fundamentals of Finance & Accounting:


**Reference books:**

#### Microeconomics:


**Reference books:**

#### Macroeconomics:


**Reference books:**

#### Econometrics:


**Reference books:**

#### Money Banking & Financial Markets:


**Reference books:**

#### Public Finance – Theory and Practice:


**Reference books:**

#### Economics of Growth and Planning:

**International Trade and Balance of Payments:**

**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:**
- Wishwa Prakashan, A division of New Age International(P) Ltd., 2005

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**Mathematics**

**Algebra**
- Permutations, combinations, pigeon-hole principle, inclusion-exclusion principle, derangements. Fundamental theorem of arithmetic, divisibility in \( \mathbb{Z} \), congruences, Chinese Remainder Theorem, Euler \( \phi \)-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.
- Series and sequences of functions, uniform convergence.
- 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:**

**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.

**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.

**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, McGraw hill Publisher.

**Linear Algebra**
- 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.
### 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


### 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.


### 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).


### 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.


### 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.


### Advanced Calculus

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


### Modern Physics


Reference books:

### Thermodynamics & Properties of Matter

| **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 |

| **Electromagnetic Theory** |

| **Quantum Mechanics** |

| **Methods of Mathematical Physics** |
| Vector Analysis, Curvilinear Coordinates, Matrices and Vector Spaces, Functions of Complex Variables, Ordinary Differential Equations, Sturm-Liouville Theory and Special Functions, Elements of Partial Differential Equations |

| **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 |

| **Solid State Physics** |

| **Optics & Spectroscopy** |
| Geometrical Optics, Interference, Diffraction, Polarization, Crystal Optics & Lasers, Atomic & Molecular Spectroscopy |

| **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 |

| **Languages** |
| Modern 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, Canadian Literature |

| **Humanities** |
| **Dynamics of social change** |
roles, culture and personality, social responsibility, Social stratification: caste, class, function and their changing pattern, Social change: Concept, theories and process of social change, factors, resistance, progress, social development, Industry and social change: modernization and urbanization, Social disorganization and delinquency

**Reference books:**
- Steve Bruce, Sociology: A very short Introduction, New York: Oxford University Press. 1999

### Conflict Management

Introductions to conflict Management: An Overview, Characteristics and dynamics of conflict, Reasons for conflict, the value of conflict in social change. The different approaches to addressing and managing conflict. Conflict analysis: Examining the history and impacts of a conflict, identifying the causes of conflict, Identifying who the stakeholder are and their interest, Exploring stakeholder power and relationships. Developing a strategy for Managing conflict. Assessment of options to address conflict, Tools for determining the best strategy, Incentives and methods in getting stakeholder to collaborate, Communication, Mediation and Facilitation, Active listenin, Skills in mediation and facilitation, Roles of mediator and facilitator in conflict management, Dealing with emotions and difficult situations, Negotiating Agreements, Planning and preparing for negotiations, Improving negotiation skill to enhance the negotiated result, Joint problem solving approaches, Building agreements, Conflict Anticipation and Prevention, Building conflict management mechanisms, Consensus-building strategies

**Reference books:**
- The Dynamics of Conflict Resolution, San Francisco: Wiley Company, 2000

### Contemporary India

Society, tradition and autonomy, Changing Social Structure in contemporary India, the explosion of middle class, women: From equality to empowerment, development policy in India, Agriculture and Industry, Democracy: From consolidation to fluidity: Fundamental rights and duties; Civil service; continuity and change; India’s foreign Policy, Salient features of Indian constitution

**Reference books:**
- Independent India : The First Fifty Years, edited by Hiranmay Kalekar, New delhi, Oxford University Press, 1995

### Computer Science

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


**Reference books:**

#### Fluid Flow Operations


**Reference books:**

#### 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:**

#### Mass Transfer Operations

Molecular diffusion and mass transfer coefficients, Interphase mass transfer, Gas absorption, Distillation, Liquid extraction and leaching.
### Reference books:

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

### Reference books:

### Selected Chemical Engineering Operations

### Reference books:

### 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:

### 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:

### 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:

### 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: