Ph.D. Entrance Test Syllabus for Ph.D in Science (All Branches)

The PET (Ph.D. Entrance test) for **Ph.D. in Science (All Branches)** consists of **two parts:**

- **Part I:** Research Methodology (50 marks) and
- **Part II:** Subject Specific (Related to the branch for 50 marks)

Total Marks for PhD Entrance Test: 100 Marks

The Syllabus for Research Methodology is common to all branches of Science

SYLLABUS

Part I: Research Methodology (50 Marks)

1) Foundation of Research: Meaning, Objectives, Motivation, Utility. Concept of theory, Empiricism, deductive and inductive theory. Characteristics of scientific method -Understanding the language of research - Concept, Construct, definition, Variable. Research Process.

2) Problem Identification & Formulation: Definition and formulating the research problem, Necessity of defining the problem, Importance of literature review in defining a Problem, Research Question - Investigation Question - Measurement Issues - Hypothesis- Qualities of a good hypothesis - Null hypothesis & Alternative Hypothesis. Hypothesis Testing - Logic & importance.

3) Research Design: Concept and Importance in Research - Features of a good research Design - Exploratory Research Design - Concept, Types and uses, Descriptive Research Design - concept, types and uses. Experimental Design - Concept of Independent &Dependent variables.

4) Qualitative and Quantitative Research: Qualitative - Quantitative Research - Concept of Measurement, causality, generalization, replication. Merging the two approaches.

5) Data Collection and analysis: Execution of the research - Observation and Collection of Data - Methods of data collection, hypothesis-testing - Generalization and Interpretation.

6) Measurement: Concept of measurement - what is measured? Problem in measurement In research - Validity and Reliability. Levels of measurement - Nominal, Ordinal, Interval, Ratio.

7) Sampling: Concept of Statistical population, Sample, Sampling Frame, Sampling Error, Sample size, Non-Response. Characteristics of a good sample. Probability Sample -Simple Random Sample, Systematic Sample, Stratified Random Sample & Multi-stage Sampling. Determining size of the sample - Practical considerations in sampling and Sample size.

8) Data Analysis: data Preparation - Univariate analysis (frequency tables, bar charts, pie Charts, percentages), bivariate analysis - Cross tabulations and Chi-square test including testing hypothesis of association.

9) Interpretation of Data and Paper Writing: Layout of a Research Paper, Journals in Computer Science, Impact factor of journals, When and where to publish? Ethical issues Related to publishing, Plagiarism and Self-Plagiarism. Use of Encyclopedias, Research Guides, Handbook etc., Academic databases for concerned discipline.

10) Use of tools / techniques for Research: methods to search required information Effectively, Reference Management Software like Zotero/Mendeley, Software for paper Formatting like Latex/MSOffice, Software for detection of plagiarism.

11) Reporting and Thesis writing: Structure and components of scientific reports - Types of Report - Technical Reports and Thesis - Significance - Different steps in the preparation -Layout, Structure and Language of typical reports - Illustrations and Tables -Bibliography, Referencing and Footnotes - Oral presentation - Planning - Preparation -Practice - Making presentation - Use of visual aids - Importance of effective Communication.

12) Application of results and ethics: Environmental impacts - Ethical issues – Ethical committees - Commercialization - Copyright - Royalty - Intellectual property rights and Patent law - Trade related aspects of intellectual property Rights - Reproduction of Published material - Plagiarism - citation and acknowledgement - citation and Acknowledgement - Reproducibility and accountability.

13) Reasoning and Mental ability: Analogy, Classification, Series, Coding-Decoding, Direction Sense, Representation through Venn Diagrams, Mathematical Operations, Arithmetical Reasoning, Inserting the Missing Character, Number, Ranking and Time Sequence Test, Eligibility Test, Representation through Venn-diagrams, Number &Symbols ordering, Comprehension questions, Statement & assumptions, Statement &Conclusions, Statement & actions.

Books Recommended;

1) Research Methodology - C. R. Kothari
2) Research Methodology: An Introduction - Stuart Melville and Wayne
3) Practical Research Methods - Catherine Dawson
4) Select references from the Internet

Reference Books:

1) Garg, B. L., Karadia, R., Agarwal, F. and Agarwal, U. K., 2002. An introduction to Research Methodology, RBSA Publishers.
2) Kothari, C.R., 1990. Research Methodology: Methods and Techniques. New Age International. 418p.
3) Sinha, S. C. and Dhiman, A. K., 2002. Research Methodology, EssEss Publications. 2Columns.
4) Trochim, W. M. K., 2005. Research Methods: the concise knowledge base, Atomic Dog Publishing. 270p
5) Wadehra, B. L. 2000. Law relating to patents, trademarks, copyright designs and Geographical indications. Universal Law Publishing.

For Additional Reading:

1) Anthony, M., Graziano, A. M. and Raulin, M. L., 2009. Research Methods: A Process ofInquiry, Allyn and Bacon.
2) Carlos, C. M., 2000. Intellectual property rights, the WTO and developing countries: theTRIPS agreement and policy options. Zed Books, New York.
3) Coley, S. M. and Scheinberg, C. A., 1990, "Proposal Writing", Sage Publications.
4) Day, R. A., 1992. How to Write and Publish a Scientific Paper, Cambridge University Press.
5) Fink, A., 2009. Conducting Research Literature Reviews: From the Internet to Paper. Sage Publications
6) Leedy, P. D. and Ormrod, J. E., 2004 Practical Research: Planning and Design, Prentice Hall.
7) Satarkar, S. V., 2000. Intellectual property rights and Copyright. EssEss Publications

The syllabus for each branch of Science (subject specific) is given below:

- **Ph.D. in Computer Science**
- **Ph.D. in Physics**
- **Ph.D. in Chemistry**
- **Ph.D. in Mathematics and Statistics**
- **Ph.D. in Biotechnology**
- **Ph.D. in Microbiology**
- **Ph.D. in Biochemistry**

Ph.D. in Computer Science

Part II: Subject Specific Syllabus (50 Marks)

1) Theory of Computing:
Growth of Functions, Divide-and-Conquer, Probabilistic Analysis and Randomized Algorithms, Heap sort, Quicksort, Sorting in Linear Time, Hash Tables, Binary Search Trees, Red-Black Trees, Dynamic Programming, Greedy Algorithms, B-Trees, Elementary Graph Algorithms, Minimum Spanning Trees, Single-Source Shortest Paths, All-Pairs Shortest Paths, Maximum Flow, Multithreaded Algorithms, Linear Programming, String Matching, NP-Completeness, Finite Automata and Regular Expressions, Properties of Regular Sets, Context Free Grammars, Push down Automata, Properties of Context Free Languages, Turing Machines, Undesirability, Chomsky Hierarchy.

2) Operating Systems:
Introduction to Operating System, Operating-System Structures, Process Management: Processes, Threads, CPU Scheduling, Process Synchronization, Deadlocks, Memory Management: Main Memory, Virtual Memory, And Storage Management: File-System Interface, File-System Implementation, Mass-Storage Structure, I/O Systems, Protection and Security: Protection, Security, Distributed Systems: Distributed System Structures, Distributed File Systems, Distributed Coordination, Special-Purpose Systems: Real-Time Systems, Multimedia Systems, General Overview of the System, Introduction To The Kernel, the Buffer Cache, Internal Representation of Files, System Calls For the Filesystem, the Structure of Processes, Process Control, Process Scheduling and Time, Memory Management Policies, the I/O Subsystem, Interposes Communication, Multiprocessor Systems, Distributed UNIX Systems.

3) Computer Architecture:
Fundamentals of Quantitative Design and Analysis, Memory Hierarchy Design, Instruction-Level Parallelism and Its Exploitation, Data-Level Parallelism in Vector, SIMD, and GPU Architectures, Thread-Level Parallelism, Warehouse-Scale Computers to Exploit Request-Level and Data-Level Parallelism, Computer Abstractions and Technology, Instructions: Language of the Computer, Arithmetic for Computers, Assessing and Understanding Performance, the Processor: Data path and Control, Enhancing Performance with Pipelining, Large and Fast: Exploiting Memory Hierarchy, Storage, Networks, and Other Peripherals, Multiprocessors and Clusters.

4) **Information Systems and Information Retrieval:**
Overview of Database Systems, Introduction to Database Design, the Relational Model, Relational Algebra and Calculus, SQL: Queries, Constraints, Triggers, Database Application Development, Internet Applications, Overview of Storage and Indexing, Storing Data: Disks and Files, Tree- Structured Indexing, Hash-Based Indexing, Overview Of Query Evaluation, External Sorting, Evaluating Relational Operators, A Typical Relational Query Optimizer, Overview of Transaction Management, Concurrency Control, Crash Recovery, Schema Refinement and Normal Forms, Physical Database Design and Tuning, Security and Authorization, Parallel and Distributed Databases, Object-Database Systems, Deductive Databases, Data Warehousing and Decision Support, Data Mining, Information Retrieval and XML Data, Spatial Data Management.

5) **Networking:**
Concept of layering. LAN technologies (Ethernet). Flow and error control techniques, Switching. IPv4/IPv6, routers and routing algorithms (distance vector, link state).TCP/UDP and sockets, congestion control. Application layer protocols (DNS, SMTP, POP, FTP, HTTP). Basics of Wi- Fi. Network security: authentication, basics of public key and Private Key cryptography, digital signatures and certificates, firewalls.

6) **Programming Languages and Translators:**
Introduction to Programming Languages, Language Description: Syntactic Structure, Statements: Structured Programming, Types: Data Representation, Procedure Activations, Groupings of Data and Operations, Object-Oriented Programming, Elements of Functional Programming, Functional Programming in a Typed Language, Functional Programming with Lists, Logic Programming, an Introduction to Concurrent Programming, Semantic Methods, Static Types and the Lambda Calculus, Introduction to Compiling, A Simple One-Pass Compiler, Lexical Analysis, Syntax Analysis, Syntax-Directed Translation, Type Checking, Run-Time Environments, Intermediate Code Generation, Code Generation, Code Optimization, Linking and Loading, Architectural Issues, Object Files, Storage Allocation, Symbol Management, Libraries, Relocation, Loading and Overlays, Shared Libraries, Dynamic Linking and Loading, Advanced Techniques, Introduction to System Software, Assemblers, Loaders and Linkers, Macro Processors, Compilers, Operating Systems, Other System Software, Software Engineering Issues.

7) **Computer Graphics:**
Introduction to Computer Graphics, Introduction to 2D Graphics Using WPF, an Ancient Renderer Made Modern, A 2D Graphics Test Bed, an Introduction to Human Visual Perception, Introduction to Fixed-Function 3D Graphics and Hierarchical Modelling, Essential Mathematics and the Geometry of 2-Space and 3-Space, A Simple Way to Describe Shape in 2D and 3D, Functions on Meshes, Transformations in Two Dimensions, Transformations in Three Dimensions, A 2D and 3D Transformation Library for Graphics, Camera Specifications and Transformations, Standard Approximations and Representations, Ray Casting and Rasterization, Survey of Real-Time 3D Graphics Platforms, Image Representation and Manipulation, Images and Signal Processing, Enlarging and Shrinking Images, Textures and Texture Mapping, Interaction Techniques, Splines and Subdivision Curves, Splines and Subdivision Surfaces, Implicit Representations of Shape, Meshes, Light, Materials and Scattering, Colour, Light Transport, Probability and Monte Carlo Integration, Computing Solutions to the Rendering Equation: Theoretical Approaches, Rendering in Practice, Shaders, Expressive Rendering, Motion, Visibility Determination, Spatial Data Structures, Modern Graphics Hardware.

8) **Artificial Intelligence:**
Artificial Intelligence, Intelligent Agents, Solving Problems by Searching, Beyond Classical Search, Adversarial Search, Constraint Satisfaction Problems, Logical, First- Order Logic, Inference in First-Order Logic, Classical Planning, Planning and Acting in the Real World, Knowledge Representation, Quantifying Uncertainty, Probabilistic Reasoning, Probabilistic Reasoning over Time, Making Simple Decisions, Making Complex Decisions, Learning from Examples, Knowledge in Learning, Learning Probabilistic Models, Reinforcement Learning,

Natural Language Processing, Natural Language for Communication, Perception, Robotics, Philosophical Foundations, AI: The Present and Future.

9) **Mathematics of Computation:**
Discrete Mathematics: Propositional and first order logic. Sets, relations, functions, Partial orders and lattices. Groups. Graphs: connectivity, matching, coloring. Combinatory: counting, recurrence relations, generating functions. Linear Algebra: Matrices, determinants, system of linear equations, eigenvalues and eigenvectors, LUDecomposition. Calculus: Limits, continuity and differentiability. Maxima and minima. Mean value theorem. Integration. Probability: Random variables. Uniform, normal ,Exponential, Poisson and binomial distributions. Mean, median, mode and standard Deviation. Conditional probability and Bayes theorem.

10) **Programming and Data Structure:** Recursion. Arrays, stacks, queues, linked lists, trees, Binary search trees, binary heaps, graphs.

References:

1 Introduction to Algorithms, Cormen, Leirseron, Rivest, Klein, MIT Press.
2 Introduction to Automata theory, Languages and Computation, John E. Hopcroft, RajeevMotwani, Jeffrey D. Ullman, Pearson Education.
3 Operating System Concepts, Abraham Silberschatz, Peter Baer Galvin, Greg Gagne, JohnWiley Publication.
4 The Design of UNIX Operating System, M. Bach, Pearson Education.
5 Computer Architecture: A Quantitative Approach, J. Hennessy, D. Patterson, Pub.Morgan Kaufmann
6 Computer Organization and Design, J. Hennessy, D. Patterson, Elsevier India PrivateLimited
7 Database Management Systems, Raghu Ramakrishnan and Johannes Gehrke, McGraw-Hill Higher Education
8 Computer Networks, A. Tanenbaum, Pearson Education
9 Programming Languages: Concepts and Constructs, Ravi Sethi, Addison Wesley
10 Compilers: Principles, Techniques and Tools, Alfred V. Aho, Monica S. Lam, Ravi Sethiand Jeffrey D. Ullman, Pearson Education
11 Linker and Loaders, J. Levin, Morgan-Kaufmann
12 System Software: An Introduction to System Programming, Leland L. Beck, Pearson Education
13 Computer Graphics: Principles and Practice in C, James D. Foley, Andries van Dam,Steven K. Feiner, John F. Hughes, Addison Wesley
14 Artificial Intelligence: A Modern Approach 3rd Edition, Stuart Russell and Peter Norvig,Prentice Hall
15 Discrete Math by Tremblay Manohar
16 Predicate Calculus and Program Semantics by Dijkstra
17 Logic in Computer Science: Modelling and Reasoning about Systems, by Michael Huth,Mark Ryan Cambridge Univeristy Press
18 Concrete Mathematics, A Foundation for Computer Science, Graham, R. M., D. E., Knuth& O. Patashnik [1989], Addison Wesley
19 Numerical Methods for Scientists and Engineers, Chapra, TMH
20 Elements of Numerical Analysis, Peter Henrici, John Wiley & Sons.
21 Numerical Linear Algebra, Leslie Fox, Oxford University Press

Ph.D. in Physics

Part II: Subject Specific syllabus (50 Marks)

1. **Mathematical Methods of Physics:** Dimensional analysis. Vector algebra and vector calculus. Linear algebra, matrices, Eigenvalues and eigenvectors. Ordinary and partial Differential equations of first and second order, Special functions (Hermite, Bessel, Laguerre and Legendre functions). Fourier series, Fourier and Laplace transforms. Elements of complex analysis, analytic functions; Taylor & Laurent series; poles, residues and evaluation of integrals. Elementary probability theory, Central limit theorem, :root of functions, interpolation, extrapolation, integration by trapezoid and Simpson's rule, Finite difference methods, Tensors.

2. **Classical Mechanics:** Central force motions. Two body Collisions - scattering in laboratory and Centre of mass frames. Rigid body dynamics- moment of inertia tensor. Non-inertial frames and pseudoforces. Variational principle. Generalized coordinates. Lagrangian and Hamiltonian formalism and equations of motion. Conservation laws and cyclic coordinates. Periodic motion: small oscillations, normal modes. Special theory of relativity- Lorentz transformations, relativistic kinematics and mass–energy relation, Poisson brackets and canonical transformations. Symmetry, invariance and Noether's theorem. Hamilton-Jacobi theory.

3. **Electromagnetic Theory:** Electrostatics: Gauss's law and its applications, Laplace and Poisson equations, Magnetostatics: Biot-Savart law, Ampere's theorem. Electromagnetic induction. Maxwell's equations, boundary conditions on the fields at interfaces. Scalar and vector potentials, gauge invariance. Electromagnetic waves in free space. Dielectrics and conductors. Fresnel's law, Dynamics of charged particles in static and uniform electromagnetic fields, Lorentz invariance of Maxwell's equation. Radiation- from moving charges and dipoles

4. **Quantum Mechanics:** Wave-particle duality. Schrödinger equation (time-dependent and time-independent). Eigenvalue problems (particle in a box, harmonic oscillator, etc.). Tunneling through a barrier. Wave-function in coordinate and momentum representations. Commutators and Heisenberg uncertainty principle. Dirac notation for state vectors. Motion in a central potential: orbital angular momentum, angular momentum algebra, spin, addition of angular momenta; Hydrogen atom. Stern-Gerlach experiment. Time- independent perturbation theory and applications. Variational method. Time dependent perturbation theory and Fermi's golden rule, selection rules. Identical particles, Pauli exclusion principle, WKB approximation

5. **Thermodynamic and Statistical Physics:** Laws of thermodynamics and their consequences. Thermodynamic potentials, Maxwell relations, chemical potential, phase equilibria. Phase space, micro- and macro-states. Micro-canonical, canonical and grand- canonical ensembles and partition functions. Free energy and its connection with thermodynamic quantities. Classical and quantum statistics. Ideal Bose and Fermi gases.

Blackbody radiation and Planck's distribution law, Bose-Einstein condensation. Diffusion equation. Random walk and Brownian motion. Introduction to nonequilibrium processes.

6. **Electronics and Experimental Methods:** Semiconductor devices (diodes, transistors, field effect devices, homo- and hetero-junction devices), device structure, device characteristics, frequency dependence and applications. Opto-electronic devices (solar cells, photo-detectors, LEDs). Digital techniques and applications (registers, counters, comparators and similar circuits). A/D and D/A converters. Microprocessor and microcontroller basics. Transducers (temperature, pressure/vacuum, magnetic fields, vibration, optical, and particle detectors) Data interpretation and analysis. Precision and accuracy. Error analysis, propagation of errors. Least squares fitting,

7. **Atomic & Molecular Physics:** Quantum states of an electron in an atom. Electron spin. Spectrum of helium and alkali atom. hyperfine structure and isotopic shift, width of spectrum lines, LS & JJ couplings. Zeeman, Paschen-Bach & Stark effects. Electron spin resonance. Nuclear magnetic resonance, chemical shift. Frank-Condon principle. Born- Oppenheimer approximation. Electronic, rotational, vibrational and Raman spectra of diatomic molecules, selection rules. Lasers: spontaneous and stimulated emission, Optical pumping, population inversion

8. **Condensed Matter Physics:** Bravais lattices. Reciprocal lattice. Diffraction and the structure factor. Bonding of solids. Elastic properties, phonons, lattice specific heat. Free electron theory and electronic specific heat. Response and relaxation phenomena. Drude model of electrical and thermal conductivity. Hall effect and thermoelectric power. Electron motion in a periodic potential, band theory of solids: metals, insulators and semiconductors. Superconductivity: type-I and type-II superconductors. Josephson junctions. Superfluidity. Defects and dislocations. Quasi crystals.

9. **Nuclear and Particle Physics:** Basic nuclear properties: size, shape and charge distribution, spin and parity. Binding energy, semi- empirical mass formula, liquid drop model. Shell model, Nature of the nuclear force, , charge-independence and charge- symmetry of nuclear forces. Deuteron problem. Rotational spectra. Elementary ideas of alpha, beta and gamma decays and their selection rules. Fission and fusion. Nuclear reactions, reaction mechanism, compound nuclei and direct reactions. Classification of fundamental forces. Elementary particles and their quantum numbers (charge, spin, parity, isospin, strangeness, etc.). Quark model, baryons and mesons. C, P, and T invariance. Application of symmetry arguments to particle reactions. Parity non-conservation in weak interaction. Relativistic kinematics.

Reference Books for Part I: Physics

Sr No.	Subject		Reference Book
1	Mathematical Methods of Physics	I	Mary L. Boas, Mathematical Methods in the Physical Sciences, 3rd edition, Wiley India (2011).
		II	G. B. Arfken and H.J. Weber, Mathematical Methods for Physicists, 5th edition, Academic Press (2001).
2	Classical Mechanics	I	Classical Mechanics Jog & Rana (Tata McGraw-Hill)
		II	Introduction to Classical Mechanics. By R. G. Takwale, P. S. Puranik.
3	Electromagnetic Theory	I	J. D. Jackson, Electrodynamics
		II	David J Griffiths, Introduction to Electrodynamics
4	Quantum Mechanics	I	Quantum Mechanics, D. J. Griffiths (Pearson Education)
		II	Quantum mechanics: Theory and applications, A. Ghatak and S. Lokanathan (Springer)
5	Thermodynamic and Statistical Physics	I	Statistical Mechanics, F. Reif (Waveland Press)
		II	An Introduction to Statistical Mechanics and Thermodynamics, R. H. Swendsen (Oxford University Press)
6	Electronics and Experimental Methods	I	Integrated Electronics, Analog and Digital Circuits and Systems, J. Milman and C.C. Halkias McGraw Hill Kogakusha ltd; International Student Edition (1972)
		II	Electronic Fundamentals And Applications: Integrated And Discrete Systems 5th Edition (English, Paperback, John D. Ryder)
7	Atomic & Molecular Physics	I	Physics of Atoms and Molecules, BH Bransden, CJ Joachain, 2008, Pearson Education Ltd
		II	Atomic and molecular physics: (for B.Sc. and M.Sc. students of Indian univ.), Raj Kumar
8	Condensed Matter Physics	I	Charles Kittel, Introduction to Solid State Physics, 8th Edition, John Wiley & Sons, Inc, (2012)
		II	A.J Dekker, Solid State Physics, Macmillan Publishers India Private Limited, 1st Ed. (2000)
9	Nuclear and Particle Physics	I	Concepts of Nuclear Physics, B.L. Cohen (Tata McGraw Hill)
		II	Nuclear Physics. Irving Kaplan (Addison-Wesley Publishing Company. Inc.)

Ph.D. in Chemistry

Part II: Subject Specific syllabus (50 Marks)

- Concepts of acids and bases, Hard-Soft acid base concept, Non-aqueous solvents.
- Transition elements and coordination compounds: structure, bonding theories, spectral and magnetic properties, reaction mechanisms.
- Organometallic compounds: synthesis, bonding and structure, and reactivity. Organometallics in homogeneous catalysis
- Chemical bonding in Diatomics; elementary concepts of MO and VB theories; Huckel theory for conjugated π-electron systems.
- Electrochemistry: Nernst equation, redox systems, electrochemical cells; DebyeHuckel theory; electrolytic conductance – Kohlrausch's law and its applications; ionic equilibria; conductometric and potentiometric titrations.
- Polymer chemistry: Molar masses; kinetics of polymerization.
- Principles of stereochemistry: Configurational and conformational isomerism in acyclic and cyclic compounds; stereogenicity, stereoselectivity, enantioselectivity, diastereoselectivity and asymmetric induction.
- Organic reactive intermediates: Generation, stability, and reactivity of carbocations, carbanions, free radicals, carbenes, benzynes and nitrenes.
- Organic reaction mechanisms involving addition, elimination, and substitution reactions with electrophilic, nucleophilic or radical species. Determination of reaction pathways.
- Organic transformations and reagents: Functional group interconversion including oxidations and reductions; common catalysts and reagents (organic, inorganic, organometallic and enzymatic). Chemo, regio, and stereoselective transformations.
- Concepts in organic synthesis: Retrosynthesis, disconnection, synthons, linear and convergent synthesis, umpolung of reactivity and protecting groups.
- Structure determination of organic compounds by IR, UV-Vis, 1H & 13C NMR and Mass spectroscopic techniques.
- Catalysis and green chemistry.

Reference Books:

1. Modern methods of Organic Chemistry by William Carruthers, Cambridge University Press
2. Organic Chemistry by Jonathan Clayden, Nick Greeves and Stuart Warren,Oup Oxford
3. Principles of Inorganic Chemistry by B.R. Puri, L.R. Sharma and K.C.Kalia,Vishal Publishing company
4. Inorganic Chemistry: Principles, of structure and Reactivity by James E Huheey, Ellen A. keiter, Richard L. Keiter,Pearson education India.
5. Physical Chemistry by Peter Atkins, Julio De Paula,Oxford HED Publications
6. Essentials of Physical chemistry by Arun Bahl, B.S. Bahl and G.D. Tuli,Mittal Books India.

Ph.D. in Mathematics and Statistics

Part II: Subject Specific syllabus (50 Marks)

1) Algebra

Modern Algebra - Groups, Sylow Package Theorems, Rings, PID, UFD, Fields, Field Extension, Finite Fields.

Linear Algebra – Algebra of Linear Transformation, Finite Dimensional Vector Spaces, Diagonazibility, Hermitian & Unitary Transformations, Spectral Theorem.

Reference Books:

1). I.N. Herstein, Topics in Algebra, Wiley Eastern Ltd. New Delhi, 1975.

2). P.B. Bhattacharya, S.K. Jain and S.R. Nag Paul, Basic Abstract Algebra (2nd Edition), Cambridge University Press; Indian Edition, 1997.

3). M.Artin, Algebra, Prentice Hall of India, 1991.

4). Vivek Sahai and Vikas Bist, Algebra, Narosa Publishing House, 1999.

2) Real Analysis

Limit of Functions, Continuous Functions, Continuity and Compactness, Continuity and Connectedness, Discontinuities, Monotonic Functions, Infinite Limits & Limit at Infinity. Derivative of Real Function, Mean Value Theorem, Continuity of Derivatives, L'Hospital's rule, Derivatives of Higher Order, Taylor's Theorem.

Reference Books:

1). T.M. Apostol, Mathematical Analysis, Narosa Publishing House, New Delhi, 1985.

2). R.G.Bartle, The elements of integration, John Wiley & Sons, Inc.New York.

3). Walter Rudin Principles of Mathematical Analysis' (3rd Edition).

3) Complex Analysis

Analytic Functions, Conformal Mappings, Bilinear Transformation, Complex Integration, Cauchy's Integral Theorem, Zeros & Singularities, Taylor's & Laurent's series, Residue theorem.

Reference Books:

1). Ahlfors, L.V., Complex Analysis. McGraw-Hill Book Company, 1979.

2). Churchill, R.V. and Brown, J.W., Complex Variables and Applications McGraw Hill Publishing Company 1990.

3). Conway, J.B., Functions of One complex variables Narosa Publishing, 2000.

4). S.Ponnusamy, Foundations of Complex Analysis, Narosa Publishing House, 1997.

4) Differential Equations

ODE - Linear Differential Equations with Constant Coefficients, Existence and Uniqueness of Solution, Picard's Theorem, Applications of Linear Differential Equations, Boundary Value Problems.

PDE – Linear & quasilinear first order PDE, Method of Characteristics, Second order linear equations in two variables and their classification.

Reference Books:

1). E.A. Coddington and N. Levinson, Theory of Ordinary Differential Equations, Tata McGraw-Hill , 2000.
2). P. Hartman, Ordinary Differential Equations, John Wiley & Sons NY, 1971.
3). D. Somasundaram, Ordinary Differential Equations, A first Course, Narosa Pub., 2001.
4). S.L. Ross, Differential Equations, John Wiley & Sons.
5). L.C. Evans, Partial Differential Equations, Graduate Studies.
6). I.N. Snedden, F. John, P. Prasad and R. Ravindran, Amarnath, Partial Differential Equation.

5) Numerical Methods

Interpolation, Numerical Differentiation & Integration, Numerical solution of systems of linear equations, Solution of IVP's.

Reference Books:

1) S.S. Sastry, Introductory Methods of Numerical Analysis.
2). James F. Epperson, An Introduction to Numerical Methods & Analysis.

6) Combinatorics

Counting Principles, Generating Functions, Recursion, Boolean Algebra, Distributive Lattices, Graphs, Trees, Connectivity & Coloring of Graphs.

Reference Books:

1). Alan Tucker, Applied Combinatorics, Wiley, 1995.
2). Richard A. Brualdi, Introductory Combinatorics, Elsevier, North-Holland, New York, 1977.
3). V. K. Balakrishnan, Combinatorics, Schuam Series, 1995.

7) **Calculus of Several Variables**
Limit, Continuity, Differentiability, Implicit Function theorem, Integration of vector functions (Line, Surface, Volume integrals).

Reference Books:

1). C. H. Edwards, Jr., Advanced Calculus of Several Variables,, Academic Press, New York, 1973 edition.
2) Sudhir R Ghorpade and Balmohan V. L., A Course in Multivariable Calculus 7 Analysis.
3). Tom M Apostol, Calculus: Multi-Variable Calculus & Linear Algebra with Applications to Differential Equations & Probability.

Ph.D. in Biotechnology

Part II: Subject Specific syllabus (50 Marks) Life Science Stream

Subjects covered under Life Sciences include microbiology, biochemistry, molecular biology, cell biology, physiology, genetics, human nutrition, biotechnology, bioinformatics, biophysics, immunology, pharmacology, zoology, botany, veterinary science, environmental sciences, and public health.

a) **Molecular and Cell Biology**: Structure of atoms, molecules and chemical bonds; Composition, structure and function of biomolecules (nucleic acids, proteins, carbohydrates, lipids and vitamins); Enzymes, biological hierarchy, Organelles, Cell Membrane, Cell cycle and apoptosis, Cytoskeleton, Genome structure and organization, Fundamental processes in Life sciences: Central Dogma, Replication, Transcription, Translation, Post Translational Modifications, DNA damage and repair, RNA synthesis and processing Recombination and transposition, Control of gene expression. Prokaryotic and Eukaryotic cells: Microorganisms, Animal cells, plant cells, viruses.

b) **Cellular Communication and Cell Signaling**: Types of cellular communications, Cell signaling - Hormones and their receptors, cell surface receptor, signal transduction pathways, second messengers, regulation of signaling pathways, Cellular communication and regulation, Chemotaxis in bacteria, quorum sensing, light signaling in plants, cell adhesion and roles of different adhesion molecules, gap junctions, extracellular matrix, integrins, neurotransmission and its regulation, Protein-protein interactions.

c) **Biochemistry, Microbiology and Virology**: Enzymology, Metabolism, Bioenergetics, Thermodynamics, Macromolecular chemistry, secondary metabolites, Classification of plant and animal viruses, Classification of microorganisms, Microbial metabolism, antimicrobial agents, Morphology and ultrastructure of viruses, Replication of viruses Retroviruses, Viral vectors, Viral vaccines.

d) **Immunology**: Innate & Acquired Immune system, Types of immune cells: B cell, T cell, Antibody structure and classification, Antigen processing and presentation, MHC, Complement activation Hypersensitivity, Autoimmunity, Techniques in cellular Immunology.

e) **Biochemical & Biophysical Techniques**: Principles of biophysical chemistry (pH, buffer, reaction kinetics, thermodynamics, colligative properties). Animal Tissue Culture, Plant Tissue Culture, rDNA Technology, Genomics and Proteomics, Genetic Engineering, Fluorescence and Absorbance Spectroscopy, Microscopy, Separation techniques.

f) **Biostatistics & Ecological Principles:** Hypothesis testing, T -test, Anova, Correlation and regression, Distribution, Mean, median, mode, standard deviation, error, Probability. Species interactions, population ecology, community ecology, conservation biology, biodiversity management.

g) **Bioinformatics, Bioimaging and Modeling in Biology**: Tools and resources and application.

h) **Applied Biosciences**: Biosensors, Transgenic animals and plants, Genomics and its application to health and agriculture, including gene therapy, Molecular Biology and Recombinant DNA methods, Isolation and purification of RNA, DNA (genomic and plasmid) and proteins, different separation methods. Analysis of RNA, DNA and proteins by one and two- dimensional gel electrophoresis, Isoelectric focusing gels. Molecular cloning of DNA or RNA fragments in bacterial and eukaryotic systems Expression of recombinant proteins using bacterial, animal and plant vectors. DNA sequencing methods, strategies for genome sequencing. Methods for analysis of gene expression at RNA and protein level, large scale expressions.

Reference Books:

1. Reece J. B., Urry L.A., Cain M. L., Minorsky P.V., Jackson R.B. (2010). Campbell's Biology, 7th edition, Publisher: Pearson.
2. Lodish H., Berk A, Kaiser C., KReiger M., Bretscher A., Ploegh H., Angelika Amon A., Matthew P., Scott M.P. (2012). Molecular Cell Biology, 7th Edition, W.H. Freeman and Co., USA
3. Nelson D. and Cox M. (2005). Lehninger Principles of Biochemistry, 4th Edition, W.H. Freeman and Company.
4. Wilson K. and Walker. J. (2018). Principles and Techniques of Biochemistry and Molecular Biology, 8th Edition, Publisher: Cambridge University Press.
5. Dubey R.C. (2014). A textbook of Biotechnology, Revised edition, Publisher: S. Chand, India

Ph.D. in Microbiology

Part II: Subject Specific Syllabus (50 Marks) Life Science Stream

Subjects covered under Life Sciences include microbiology, biochemistry, molecular biology, cell biology, physiology, genetics, human nutrition, biotechnology, bioinformatics, biophysics, immunology, pharmacology, zoology, botany, veterinary science, environmental sciences, and public health.

a) **Molecular and Cell Biology**: Structure of atoms, molecules and chemical bonds; Composition, structure and function of biomolecules (nucleic acids, proteins, carbohydrates, lipids and vitamins); Enzymes, biological hierarchy, Organelles, Cell Membrane, Cell cycle and apoptosis, Cytoskeleton, Genome structure and organization, Fundamental processes in Life sciences: Central Dogma, Replication, Transcription, Translation, Post Translational Modifications, DNA damage and repair, RNA synthesis and processing Recombination and transposition, Control of gene expression. Prokaryotic and Eukaryotic cells: Microorganisms, Animal cells, plant cells, viruses.

b) **Cellular communication and Cell Signaling**: Types of cellular communications, Cell signaling - Hormones and their receptors, cell surface receptor, signal transduction pathways, second messengers, regulation of signaling pathways, Cellular communication and regulation, Chemotaxis in bacteria, quorum sensing, light signaling in plants, cell adhesion and roles of different adhesion molecules, gap junctions, extracellular matrix, integrins, neurotransmission and its regulation, Protein-protein interactions.

c) **Biochemistry, Microbiology and Virology**: Enzymology, Metabolism, Bioenergetics, Thermodynamics, Macromolecular chemistry, secondary metabolites, Plant hormone synthesis pathways, Classification of plant and animal viruses, Classification of microorganisms, Microbial metabolism, antimicrobial agents, Morphology and ultrastructure of viruses, Replication of viruses Retroviruses, Viral vectors, Viral vaccines.

d) **Immunology**: Innate & Acquired Immune system, Types of immune cells: B cell, T cell, Antibody structure and classification, Antigen processing and presentation, MHC, Complement activation Hypersensitivity, Autoimmunity, Techniques in cellular Immunology .

e) **Biochemical & Biophysical Techniques**: Principles of biophysical chemistry (pH, buffer, reaction kinetics, thermodynamics, colligative properties). Animal Tissue Culture, Plant Tissue Culture, rDNA Technology, Genomics and Proteomics, Genetic Engineering, Fluorescence and Absorbance Spectroscopy, Microscopy, Separation techniques.

f) **Biostatistics & Ecological Principles:** Hypothesis testing, T -test, Anova, Correlation and regression, Distribution, Mean, median, mode, standard deviation, error, Probability. Species interactions, population ecology, community ecology, conservation biology, biodiversity management.

g) **Bioinformatics, Bioimaging and modeling in biology**: Tools and resources and application.

h) **Advance Microbiology**: **Microbial Physiology**: Growth yield and characteristics, strategies of cell division, stress response. Biosensors, Microbial fermentation and production of small and macromolecules, molecular approaches to diagnosis and strain identification, Bioremediation and phytoremediation, Bioresource and uses of biodiversity. **Microscopic techniques**: Visualization of cells and subcellular components by light microscopy, resolving powers of different microscopes, microscopy of living cells, scanning and transmission microscopes, different fixation and staining techniques for EM, freeze-etch and freeze-fracture methods for EM, image processing methods in microscopy. **Microbial genetics**: Methods of genetic transfers transformation, conjugation, transduction and sex-duction, mapping genes by interrupted mating, fine structure analysis of genes.

Reference Books:

1. Reece J. B., Urry L.A., Cain M. L., Minorsky P.V., Jackson R.B. (2010). Campbell's Biology, 7th edition, Publisher: Pearson.
2. Lodish H., Berk A, Kaiser C., KReiger M., Bretscher A., Ploegh H., Angelika Amon A., Matthew P., Scott M.P. (2012). Molecular Cell Biology, 7th Edition, W.H. Freeman and Co., USA
3. Nelson D. and Cox M. (2005). Lehninger Principles of Biochemistry, 4th Edition, W.H. Freeman and Company.
4. Wilson K. and Walker. J. (2018). Principles and Techniques of Biochemistry and Molecular Biology, 8th Edition, Publisher: Cambridge University Press.
5. Richard Goering, Hazel Dockrell, Mark Zuckerman, Peter Chiodini (2018). Mims' Medical microbiology and Immunology, 6th edition, Publisher: Elsevier

Ph.D. in Biochemistry

Part II: Subject Specific syllabus (50 Marks) Life Science Stream

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g) **Bioinformatics, Bioimaging and Modeling in Biology**: Tools and resources and application.

h) **Biochemical Advances:** Bioenergetics, glycolysis, oxidative phosphorylation, coupled reaction, group transfer, biological energy transducers. Isolation, separation and analysis of carbohydrate and lipid molecules. Digestion, absorption, energy balance, BMR. Light-harvesting complexes; mechanisms of electron transport; photoprotective mechanisms; CO_2 fixation-C3, C4 and CAM pathways. Plant hormones: Biosynthesis, storage, breakdown and transport; physiological effects and mechanisms of action. Respiration and photorespiration: Citric acid cycle; plant mitochondrial electron transport and ATP synthesis; alternate oxidase; photorespiratory pathway. Molecular structure determination using X-ray diffraction and NMR, Molecular analysis using light scattering, different types of mass spectrometry and surface plasmon resonance methods.

Reference Books:

1. Reece J. B., Urry L.A., Cain M. L., Minorsky P.V., Jackson R.B. (2010). Campbell's Biology, 7th edition, Publisher: Pearson.
2. Lodish H., Berk A, Kaiser C., KReiger M., Bretscher A., Ploegh H., Angelika Amon A., Matthew P., Scott M.P. (2012). Molecular Cell Biology, 7th Edition, W.H. Freeman and Co., USA
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