

Savitribai Phule Pune University

(Formerly University of Pune)

Syllabus for Ph.D. (PET) Entrance Exam : Computer Science

Research Methodology

- 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 formating 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 - Copy right - 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 Mentalability:** 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

REFERENCES

- 1) Garg, B. L., Karadia, R., Agarwal, F. and Agarwal, U. K., 2002. An introduction to Research Methodology, RBSA Publishers.
- 2) Kothati , C.R., 1990. Research Methodology: Methods and Techniques. New Age International. 418p.
- 3) Sinha, S. C. and Dhiman, A. K., 2002. Research Methodology, Ess Ess Publications. 2 columes.
- 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, trade marks, copyright designs and geographical indications. Universal Law Publishing.

Additional reading

- 1) Anthony, M., Graziano, A. M. and Raulin, M. L., 2009. Research Methods: A Process of Inquiry, Allyn and Bacon.
- 2) Carlos, C. M., 2000. Intellectual property rights, the WTO and developing countries: the TRIPS 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 Copy right. Ess Ess Publications.

Subject Concerned Syllabus Computer Science

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, Undecidability, 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, 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 File System, The Structure Of Processes, Process Control, Process Scheduling And Time, Memory Management Policies, The I/O Subsystem, Interprocess 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: Datapath 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, Color, 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. Combinatorics: counting, recurrence relations, generating functions. Linear Algebra: Matrices, determinants, system of linear equations, eigenvalues and eigenvectors, LU decomposition. 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:

- Introduction to Algorithms, Cormen, Leirseron, Rivest, Klein, MIT Press.
- Introduction to Automata theory, Languages and Computation, John E. Hopcroft, Rajeev Motwani, Jeffrey D. Ullman, Pearson Education.
- Operating System Concepts, Abraham Silberschatz, Peter Baer Galvin, Greg Gagne, John Wiley Publication.
- The Design of UNIX Operating System, M. Bach, Pearson Education.
- Computer Architecture: A Quantitative Approach, J. Hennessy, D. Patterson, Pub. Morgan Kaufmann
- Computer Organization and Design, J. Hennessy, D. Patterson, Elsevier India Private Limited
- Database Management Systems, Raghu Ramakrishnan and Johannes Gehrke, McGraw-Hill Higher Education
- Computer Networks, A. Tanenbaum, Pearson Education
- Programming Languages: Concepts and Constructs, Ravi Sethi, Addison Wesley
- Compilers: Principles, Techniques and Tools, Alfred V. Aho, Monica S. Lam, Ravi Sethi and Jeffrey D. Ullman, Pearson Education

- Linker and Loaders, J. Levin, Morgan-Kaufmann
- System Software: An Introduction to System Programming, Leland L. Beck, Pearson Education
- Computer Graphics: Principles and Practice in C, James D. Foley, Andries van Dam, Steven K. Feiner, John F. Hughes, Addison Wesley
- Artificial Intelligence: A Modern Approach 3rd Edition, Stuart Russell and Peter Norvig, Prentice Hall
- Discrete Math by Tremblay Manohar
- Predicate Calculus and Program Semantics by Dijkstra
- Logic in Computer Science: Modelling and Reasoning about Systems, by Michael Huth , Mark Ryan Cambridge Univeristy Press
- Concrete Mathematics, A Foundation for Computer Science, Graham, R. M., D. E., Knuth & O. Patashnik [1989], Addison Wesley
- Numerical Methods for Scientists and Engineers, Chapra, TMH
- Elements of Numerical Analysis, Peter Henrici, John Wiley & Sons.
- Numerical Linear Algebra, Leslie Fox, Oxford University Press