

DEPARTMENT OF COMPUTER SCIENCE AND APPLICATIONS
PH.D COURSE WORK

Semester	Paper Code	Course Title	Credits	Total
Core Courses				
I	17CSAR0101	Advanced Algorithms	4	24
	17CSAR0102	Advanced Computing Techniques	4	
	17CSAR0103	Machine Learning	4	
	17CSAR0104	Research Methodology	4	
II	17CSAR0205	Mathematical Techniques for Computer Science Specific course to be prescribed by the Doctoral Committee	4	
	17CSAR02SX		4	
	Seminar (3) Term paper/Topical Research			
III Semester onwards	Research Credits		4	
	a)Project planning including literature collection, finalization of objectives and methodology b) Field/ Lab Studies, Data collection, compilation of results, statistical analysis, results and final conclusion.		32	
End of Program	Synopsis and thesis submission, final viva		6	

List of courses that are candidate centric (17CSAR02SX)

17CSAR02S1	Image Processing
17CSAR02S2	Computer Network
17CSAR02S3	Big Data Analytics

Learning Objectives:

- To enhance the students' knowledge of algorithms and data structures
- To extend their expertise in algorithmic analysis and algorithm design techniques

Learning Outcomes:

- Analyze the performance of algorithms
- Learns how to represent complex data using advanced data structures and their implementations
- Implement algorithm design techniques in computational geometry and parallel algorithms
- Learns how to select an appropriate algorithm for solving problems of different kind.

UNIT I: FUNDAMENTALS

Mathematical Proof Techniques: Induction, Proof by Contradiction, Direct Proofs – Asymptotic Notations – Properties of Big-oh Notation – Conditional Asymptotic Notation – Algorithm Analysis – Amortized Analysis – Introduction to NP-Completeness/NP-Hard – Recurrence Equations – Solving Recurrence Equations – Time-Space Tradeoff

UNIT II: HEAP STRUCTURES

Min/Max heaps – Deaps – Leftist Heaps – Binomial Heaps – Fibonacci Heaps – Skew Heaps – Lazy-Binomial Heaps

UNIT III: SEARCH STRUCTURES

Binary Search Trees – AVL Trees – Red-Black Trees – Multi-way Search Trees – B-Trees – Splay Trees – Tries

UNIT IV: GEOMETRIC ALGORITHMS

Segment Trees – 1-Dimensional Range Searching – k-d Trees – Line Segment Intersection – Convex Hulls – Computing the Overlay of Two Subdivisions – Range Trees – Voronoi Diagram.

UNIT V: PARALLEL ALGORITHMS

Flynn's Classifications – List Ranking – Prefix Computation – Array Max – Sorting on EREW PRAM – Sorting on Mesh and Butterfly – Prefix sum on Mesh and Butterfly – Sum on Mesh and Butterfly – Matrix Multiplication – Data Distribution on EREW, Mesh and Butterfly.

REFERENCES:**Books:**

1. Ellis Horowitz, Sartaj Sahni, Dinesh Mehta, "Fundamentals of Data Structures in C++", Silicon Press, USA, 2007.
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2. Gilles Brassard, Paul Bratley, "Algorithmics: Theory and Practice", Prentice Hall, New Jersey, USA, 1988.
3. Mark de Berg, Otfried Cheong, Marc van Kreveld, Mark Overmars, "Computational Geometry Algorithms and Applications", Third Edition, Springer, 2008.
4. J.A. Storer, "An Introduction to Data Structures and Algorithms", Springer Science and Business Media, New York, USA, 2002.
5. Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest, Clifford Stein, "Introduction to Algorithms", Prentice Hall of India, New Delhi, 2006.

Journals:

1. ACM Transactions on Algorithms, Association of Computing Machinery, New York, USA (ISSN: 1549-6325)
2. Algorithms, Multidisciplinary Digital Publishing Institute (MDPI), Switzerland. (ISSN 1999-4893)
3. Journal of Algorithms, Elsevier.
4. Journal of Algorithms & Computational Technology, Sage Journals, London, UK (eISSN: 17483026 | ISSN: 17483018)

Web Resources:

1. <http://www.geeksforgeeks.org/data-structures/>
 2. <https://www.beehyve.io>
 3. <https://visualgo.net/en>
 4. <https://www.coursera.org> - Data Structures and Algorithms Specialization
 5. https://www.edx.org/course?search_query=datastuctures
 6. [https://www.pdfdrive.net/Algorithms & Data Structures](https://www.pdfdrive.net/Algorithms+%26+Data+Structures)
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UNIT I: DISTRIBUTED COMPUTING

Introduction to Distributed Computing Concepts - Basic Concepts of Distributed Systems, Distributed Computing Models - Software Concepts, Issues in Designing Distributed Systems - Client Server Model, Distributed Shared Memory

UNIT II: GRID COMPUTING

Anatomy and Physiology of Grid-Review of Web Services - The Open Grid Forum, Grid Architecture - Overview of Resource Managers, Overview of Grid Systems - Application Management

UNIT III: PERVASIVE COMPUTING

Pervasive Computing - Wearable Computing, Modeling the Key Ubiquitous/Pervasive Computing Properties - Mobile Adaptive Computing, Mobility Management and Caching - Pervasive Computing Devices, Smart Environment

UNIT IV: MOBILE COMPUTING

Differences between Mobile Communication and Mobile Computing - Contexts and Names – Functions – Applications and Services - New Applications – Making Legacy Applications Mobile Enabled - Design Considerations – Integration of Wireless and Wired Networks – Standards Bodies

UNIT V: CLOUD COMPUTING

Fundamentals of Cloud computing, Evolution of Cloud Computing - Key Characteristics of Cloud Computing - Cloud Deployment Models: Public, Private, Hybrid, Community - Categories of Cloud Computing - Everything as a Service - Infrastructure, Platform, Software - Pros and Cons of Cloud Computing – Virtualization.

REFERENCES:

Books:

1. Sunita Mahajan, Seema Shah, “Distributed Computing”, Oxford University Press, Chennai, 2010.
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2. Andrew S. Tanenbaum, “Distributed Operating Systems”, Pearson Education India, 1995.
3. Kumar Saurabh, “Cloud Computing: Unleashing Next Gen Infrastructure to Application”, Third Edition, Wiley Publication, USA, 2014.
4. Asoke K Talukder, Hasan Ahmed, Roopa R Yavagal, “Mobile Computing: Technology, Applications and Service Creation”, Second Edition, Tata McGraw Hill, India, 2010.
5. Frank Adelstein, “Fundamentals of Mobile and Pervasive Computing”, Tata McGraw Hill, India, 2005.
6. Stefan Poslad, “Ubiquitous Computing: Smart Devices, Environments and Interactions”, Wiley, USA, 2009.
7. Joshy Joseph & Craig Fellenstein, “Grid Computing”, Pearson Education, India, 2004.
8. Fran Berman, Geoffrey Fox, Anthony J.G.Hey, “Grid Computing: Making the Global Infrastructure a Reality”, John Wiley and Sons, USA, 2003.
9. D. Janakiram, “Grid Computing”, Tata McGraw Hill, India, 2005.

Web Resources:

1. <https://www.pdfdrive.net/cloud-computing-a-practical-approach-e16208074.html>
2. <https://www.pdfdrive.net/distributed-computing-e33416176.html>
3. <https://www.pdfdrive.net/grid-computing-e19175811.html>
4. <https://www.pdfdrive.net/mobile-computing-e25107056.html>
5. <https://www.pdfdrive.net/pervasive-computing-and-networking-e39583430.html>

Related Journals:

1. IEEE Transactions on Parallel and Distributed Systems
 2. IEEE Transactions on Cloud Computing
 3. IEEE Pervasive Computing
 4. IEEE Transactions on Mobile Computing
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UNIT I : INTRODOCTION

Learning Problems - Perspectives and Issues - Concept Learning - Version Spaces and Candidate Eliminations - Inductive bias - Decision Tree learning - Representation – Algorithm – Heuristic Space Search

UNIT II : NEURAL NETWORKS AND GENETIC ALGORITHMS

Neural Network Representation – Problems – Perceptrons - Multilayer Networks and Back Propagation Algorithms - Genetic Algorithms – Hypothesis Space Search - Genetic Programming - Models of Evaluation and Learning

UNIT III : BAYESIAN AND COMPUTATIONAL LEARNING

Bayes Theorem – Concept Learning – Maximum Likelihood - Minimum Description Length Principle – Bayes Optimal Classifier - Naïve Bayes Classifier – Bayesian Belief Network Probability Learning – Sample Complexity - Finite and Infinite Hypothesis Spaces – Mistake Bound Model

UNIT IV: INSTANT BASED LEARNING

K- Nearest Neighbour Learning - Locally weighted Regression - Radial Bases Functions – Case Based Learning

UNIT V: ADVANCED LEARNING

Learning Sets of Rules – Sequential Covering Algorithm - Learning Rule Set – First Order Rules – Sets of First Order Rules - Induction on Inverted Deduction –Inverting Resolution - Analytical Learning - Perfect Domain Theories – Explanation Base Learning - Reinforcement Learning – Q-Learning

REFERENCES:**Books:**

1. Tom M. Mitchell, “Machine Learning”, McGraw-Hill Science /Engineering /Math; 1st Edition, USA, 1997.
 2. Ethem Alpaydin, “Introduction to Machine Learning (Adaptive Computation and Machine Learning)”, The MIT Press, USA, 2004.
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3. T. Hastie, R. Tibshirani, J. H. Friedman, “The Elements of Statistical Learning”, Springer, 1stEdition, Germany, 2001.
4. Christopher M. Bishop, “Pattern Recognition and Machine Learning”, Springer, Germany, 2010.
5. Conway, “Machine Learning for Hackers”, O'Reilly Media, USA, 2012.
6. Ethem Alpaydi, “ Machine Learning”, Gildan Media, LLC, Canada, 2016.

Web Resources:

1. <https://www.pdfdrive.net/introduction-to-machine-learning-e21918910.html>
2. <https://www.pdfdrive.net/machine-learning-e31767902.html>
3. <https://www.pdfdrive.net/machine-learning-in-computer-vision-e2728553.html>

Related Journals:

1. IEEE Transactions on Pattern Analysis and Machine Intelligence
2. Machine Learning, Springer International Publishing



17CSAR0104

RESEARCH METHODOLOGY

Credits 4

Learning Objectives:

- To enhance the students' knowledge of algorithms and data structures
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Learning Outcomes:

- Analyze the performance of algorithms
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UNIT I: Introduction to Scientific and Computer Science Research

Objectives-Significance-Motivation of Research, Types and Approaches, Quantitative Research Methods, Research Methods versus Methodology, Research Process, Criteria of Good Research. Significance & Status of Research in Computer Science. Steps in Research: Having grounding in Computer Science, Major Journals & Publication in Computer Science, Major Research Areas of Computer Science. Identification, Selection & Formulation of Research Problem. Developing a Research Proposal, Planning your Research, The Wider Community, Resources and Tools

UNIT II: Research Problem and Design

Meaning and Selection of Research Problem, Meaning of Research Design, Need for a Research Design, Features of a Good Design. Important Concepts relating to Research Design. Different Research Designs, Basic Principles of Experimental Designs, Important Experimental Designs

UNIT III: Research Data and Literature Survey

What is Data?, Mathematical Statistics and Computer Science views on Data Analysis, Methods for Finding Associations: Regression and Pattern Recognition, Method for Aggregation and Data Visualization tools and Techniques, Finding out about your Research Area, Literature Search Strategy, Writing Critical Reviews, Identifying Venues for Publishing your Research

UNIT IV: Writing Papers, Thesis and Review Process

Preparing and Presenting your Paper, The Conference View Process, Making use of the Referees' Reports, The Journal Review Process, Group Exercise in Reviewing Research Papers, Planning the Thesis, Writing the Thesis, Thesis Structure, Writing up Schedule, The Oral Examination and Viva Voce

UNIT V: Ethical Issues and Intellectual Property

Ethics in General, Professional Ethics, Ethical Issues that Arise from Computer Technology, General Moral Imperatives, More Specific Professional Responsibilities, Organizational Leadership Imperatives. Intellectual Property Rights, Legislations covering Intellectual Property Rights in India

REFERENCES:

Books:

1. C.R. Kothari, Gaurav Garg, "Research Methodology Methods and Techniques", 3rd Edition, New Age International Publishers, Lucknow, 2014.
2. Francis C.Dane, "Research Methods", Brooks/Cole Publishing Company, California, 1990.
3. Juliet Corbin, Anselm Strauss, "Basic of Qualitative Research", 3rd Edition, Sage Publications, New Delhi, 2008.
4. Angela Brew, Routledge Falmer, "The Nature of Research: Inquiry in Academic Context", Psychology Press, New York, 2001.
5. Allen B.Tucker, jr. (Ed.), "The Computer Science and Engineering Handbook", CRC Press, Boca Raton, 1997.
6. Robin Levin Penslar (Ed.), "Research Ethics Cases and Materials", Indiana University Press, Bloomington, 1995.

Web Resources:

1. <http://desrist.org/desrist/content/design-science-research-in-information-systems.pdf>
 2. <http://study.com/academy/lesson/research-methodology-approaches-techniques-quiz.html>
 3. <https://www/0deec5215604c11e41000000/Practical-Guide-to-Write-a-PhD-Thesis-and-publish-papers-based-on-the-thesis.pdf>
 4. <https://www.bowiestate.edu/files/resources/the-fundamental-steps-to-writing-thesis.pdf>
 5. <https://www.pdfdrive.net/research-methodology-books.html>
 6. <https://www.pdfdrive.net/fundamental-of-research-methodology-and-statisticspdf-e10442087.html>
 7. <https://www.pdfdrive.net/advanced-quantitative-research-methodology-e25608453.html>
 8. <https://www.pdfdrive.net/introduction-1-research-methodology-11-the-concept-of-the-research-e870404.html>
 9. <https://www.pdfdrive.net/research-methods-in-computer-science-e31324769.html>
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17CSAR0205

**MATHEMATICAL TECHNIQUES FOR
COMPUTER SCIENCE**

Credits 4

Learning Objectives:

- To enhance the students' knowledge of algorithms and data structures
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Learning Outcomes:

- Analyze the performance of algorithms
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UNIT I: Number Theory

Number theory –Introduction, Congruences, residue classes, theorems of Fermat, Euler and Wilson, linear congruences, elementary arithmetical functions, primitive roots, quadratic residues and the law of quadratic reciprocity.

UNIT II: Graph Theory

Trees, Representations of graphs, Spanning Tree and shortest path algorithms, Planarity, Connectivity, Traversability, Colorability, Network flow algorithms, Search procedure, Recurrence relations and generating functions,

UNIT III: Probability, Statistics and Estimation:

Random experiments, Sample space, Axioms of probability, Conditional probability: Bayes' Theorem. Independent events - Probabilistic models: standard discrete, continuous models and Markov models. Minimum Mean Square Estimation (MMSE), Maximum Likelihood Estimation (MLE), linear and interval estimation. Tests of Significance, ANOVA, Regression Analysis.

UNIT IV: Integral Transform

Introduction to Fourier, and Discrete Cosine Transform, Gabor transform, Gaussian function, Centre and width of Gaussian function, Time-frequency window of Gabor transform, Advantages in using Gabor transform, time frequency window of wavelets, Discrete wavelet transform, Haar wavelet ψ and its Fourier transform, Wavelets by convolution, Mexican hat wavelet, Morlet wavelet.

UNIT V: Fuzzy Sets and Relations

Crisp Sets- An Overview- The notion of fuzzy sets- Basic concepts of fuzzy sets- Classical Logic: An Overview- Fuzzy Logic- Fuzzy Complement- Fuzzy Union- Fuzzy Intersection- Combinations of Operations- General Aggregation Operations.

Crisp and Fuzzy Relations- Binary Relations- Binary Relations on a Single set- Equivalence and Similarity Relations- Compatibility or Tolerance Relations-Ordering- Morphisms-Fuzzy Relation Equations, Fuzzy Logic.

REFERENCES:

1. D. M. Burton, "Elementary Number Theory", 6th Ed., Tata McGraw-Hill, New Delhi, 2007.
2. J.P. Tremblay and R. Manohar, "Discrete Mathematical Structures with Applications to Computer Science", 1st Ed., Tata McGraw-Hill, New Delhi, 1975.
3. K.R.Parthasarathy, "Basic Graph Theory", Tata McGraw-Hill, New Delhi, 1994.
4. Judith L. Gerstring, "Mathematical Structures for Computer Science", 5th Ed., McGraw Hill, Freeman, 2003.
5. Ralph P. Grimaldi, "Discrete and Combinatorial Mathematics - An Applied Introduction", 4th Ed., Pearson Education, 2013.
6. Yannis Viniotis, "Probability and Random Processes for Electrical Engineers", McGraw Hill International Edition, 1998.
7. Ernest Davis, "Linear Algebra and Probability for Computer Science Applications", CRC Press, 2012.
8. Y. Meyer, "Wavelets: Algorithms and Applications", SIAM, Philadelphia, 1993.
9. A.M. Wazwaz, "A First Course in Integral Equations", 1st Ed., World Scientific Publications, 1997.
10. Geroge J. Klir and Tina A.Folger, "Fuzzy Sets, Uncertainty and Information", Prentice – Hall of India Pvt. Ltd, New Delhi, 2008.
11. Timothy J.Ross, "Fuzzy Logic with Engineering Applications", 3rd Ed., Wiley, USA, 2010.

Journals:

1. Journal of Number Theory, Elsevier Publications, USA.
2. Journal of Graph Theory, Wiley Publication, Spain.
3. Statistics & Probability Letters, Elsevier Publications, Italy.
4. Integral Transform and Special Functions, Taylor & Francis.
5. Fuzzy Sets and Systems, Elsevier Publications, Belgium.

Web Resources:

1. <https://www.pdfdrive.net/burton-david-m-elementary-number-theorypdf-e30988027.html>
 2. <https://www.pdfdrive.net/discrete-mathematics-for-computer-science-e15324843.html>
 3. <https://www.pdfdrive.net/graph-theory-with-applications-e10372178.html>
 4. <https://www.pdfdrive.net/probability-and-random-processes-for-electrical-and-computer-e11436002.html>
 5. www.iausdj.ac.ir/ostad/.../Fuzzy%20Logic%20with%20Engineering%20Applications.pdf
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