

Detailed Syllabus

CC-1001	Introduction to High Performance Computing (HPC)
	<p>Program execution: Program, Compilation, Object files, Function call and return, Address space, Data and its representation. Computer organization: Memory, Registers, Instruction set architecture, Instruction processing. Pipelined processors: Pipelining, Structural, data and control hazards, Impact on programming. Virtual memory: Use of memory by programs, Address translation, Paging. Cache memory: Organization, impact on programming, virtual caches. Operating systems: Processes and system calls, Process management. Program profiling. File systems: Disk management, Name management, Protection. Parallel architecture: Inter-process communication, Synchronization, Mutual exclusion, Basics of parallel architecture, Parallel programming with message passing using MPI, Case studies.</p>
CC-1002	Computer Vision using HPC
	<p>Light, Brightness adoption and discrimination, Pixels, coordinate conventions, Imaging Geometry, Perspective Projection, Spatial Domain Filtering, sampling and quantization. Intensity transformations, contrast stretching, histogram equalization, Correlation and convolution, Smoothing filters, sharpening filters, gradient and Laplacian. Hotelling Transform, Fourier Transforms and properties, FFT, Convolution, Correlation, 2-D sampling, Discrete Cosine Transform, Frequency domain filtering. Basic Framework, Interactive Restoration, Image deformation and geometric transformations, image morphing, Restoration techniques, Noise characterization, Noise restoration filters, Adaptive filters, Linear, Position invariant degradations, Estimation of Degradation functions, Restoration from projections. Encoder-Decoder model, Types of redundancies, Lossy and Lossless compression, Entropy of an information source, Shannon's 1st Theorem, Huffman Coding, Arithmetic Coding, Golomb Coding, LZW coding, Transform Coding, Sub-image size selection, blocking artifacts, DCT implementation using FFT, Run length coding, FAX compression (CCITT Group-3 and Group-4), Symbol-based coding, JBIG-2, Bit-plane encoding, Bit-allocation, Zonal Coding, Threshold Coding, JPEG, Lossless predictive coding, Lossy predictive coding, Motion Compensation. Expansion of functions, Multi-resolution analysis, Scaling functions, MRA refinement equation, Wavelet series expansion, Discrete Wavelet Transform (DWT), Continuous Wavelet Transform, Fast Wavelet Transform, 2-D wavelet Transform, JPEG-2000 encoding, Digital Image Watermarking. Basics, SE, Erosion, Dilation, Opening, Closing, Hit-or-Miss Transform, Boundary Detection, Hole filling, Connected components, convex hull, thinning, thickening, skeletons, pruning, Geodesic Dilation, Erosion, Reconstruction by dilation and erosion. Boundary detection based techniques, Point, line detection, Edge detection, Edge linking, local processing, regional processing, Hough transform, Thresholding, Iterative thresholding, Otsu's method, Moving averages, Multivariable thresholding, Region-based segmentation, Watershed algorithm, Use of motion in segmentation, Case studies.</p>
CC-1003	Algorithms for HPC
	<p>Euclid's algorithm Problem, Instance, RAM model, RAM model 2: Asymptotic complexity Some stylistic issues Analysis of Algorithms, Principles of Algorithm Design, Finding Maximum and Minimum, Introduction, Sorting, Median Finding, Knapsack, Longest common subsequence, Matrix chain multiplication or Optimal search trees, A machine scheduling problem, Set of Intervals, Fractional Knapsack, Huffman Coding, Search/Decision, SAT, Independent_Set, 3VC, Exact Cover, Multi Set, Subset Sum & Partition, Hamiltonian Circuit, Case studies.</p>

CC-2001	Software Engineering for HPC
	<p>Introduction to Software Engineering, Requirements analysis, software design, coding, testing, maintenance, etc. Waterfall model, prototyping, interactive enhancement, spiral model. Role of Management in software development. Role of metrics and measurement. Problem analysis, requirement specification, validation, metrics, monitoring and control. Problem partitioning, abstraction, top-down and bottom-up design, Structured approach. Functional versus object-oriented approach, design specification and verification metrics, monitoring and control. Top-down and bottom-up, structured programming, information hiding, programming style, and internal documentation. Verification, Metrics, monitoring and control. Levels of testing functional testing, structural testing, test plane, test cases specification, reliability assessment. Cost estimation, Project scheduling, Staffing, Software configuration management, Quality assurance, Project Monitoring, Risk management, etc. Case studies.</p>
CC-2002	Database Design for HPC
	<p>Databases & Information Systems, Database system concepts & architecture. High-level conceptual modeling, ER Modeling concepts, ER Diagrams, Cardinality constraints, Higher-order relationships, Enhanced ER Model, Weak-entity types, Subclasses and inheritance, Specialization and Generalization, Modeling of UNION types using categories. Relational model concepts, Relational integrity constraints, Update operations on relations, Relational algebra model, ER to relational mapping. Data definition in SQL, Queries and update statements, Views, Integrity constraints, Specifying indexes, Embedded SQL. Keys in a relational model, Concept of functional dependencies, Normal forms based on primary keys, Boyce-Codd Normal Forms. Multi-values dependencies and fourth normal form, Join dependencies and fifth normal form, Inclusion dependencies, Other dependencies and normal forms. Secondary storage devices, Buffering of blocks, File Organization, Heaps, Sorted Files, Hashing & overflow handling techniques, Dynamic hashing, Extensible hashing, Other file organizations Primary indexes, Clustering index, Secondary index, Multilevel indexes, ISAM, B-trees, B+ trees, inserting and searching algorithms for B+ trees, OLTP environments, Concurrency issues, need for transactions, Necessary properties of transactions (ACID properties), Transaction states, serializability, Serial schedules, Conflict serializability, View serializability, Recoverable and non-recoverable schedules, Cascading rollbacks, Cascadeless schedules. Serialized and non-serialized schedules, Testing for serializability, Locking, Lock compatibility matrix, Locking and serializability, Deadlocks and starvation, Two-phase locking (2PL) protocol, Conservative, strict and rigorous 2PL, 2PL with lock conversions, Timestamp-ordering based protocol, Multi-versioning protocol, Multi-granularity locking, Deadlock prevention protocols, Wait-die and wound-wait schemes, Time-out based schemes, Deadlock recovery, Nested transactions. Recovery concepts, Deferred updates technique, Immediate update technique, Shadow paging, ARIES recovery algorithm. Translating SQL into relational algebra, Basic query operations, Heuristics in query optimization, Selectivity and cost estimates in query optimization, Semantic query optimization. Discretionary access control, Mandatory access control and multi-level security, Statistical database security. Active database concepts, Temporal databases, Spatial databases, multi-media databases. Data fragmentation, replication and allocation in distributed databases, Types of distributed database systems Query processing in distributed databases, Concurrency control and recovery in distributed databases, Case studies.</p>
CC-9011	Computer Organization

	Introduction To Computing & System: Software & Hardware, Processor Activities, Processor As a State Machine, Data Path Architecture, Data Path Controller : Micro Programmed, State Machine Design, Controller Design: Microprogrammed & Hardwired, Typical Micro Instructions, Addressing Modes, Introduction to memory system, CPU - Memory Interaction, Cache Organization, Virtual Memory, Performance Calculation, Segmentation, Address Translation & Protection, Programmed I/O, Interrupt Driven I/O, DMA : Direct Memory Access, Device Service Routines, Evolution Of I/O, I/O Devices, Buses, Case studies.
CC-9012	Programming and Data Structure
	Problem Decomposition By Recursion, Merge sort & Quick sort, Linked Lists, Complexity (Efficiency) of Algorithms, Asymptotic Growth Functions, Asymptotic Analysis of Algorithms, Data Structuring, Search Trees, 2-3 Trees, Graphs, Algorithm Design, Case studies.
CC-9013	Biometrics
	Introduction of Biometric traits and its aim, image processing basics, basic image operations, filtering, enhancement, sharpening, edge detection, smoothing, enhancement, thresholding, localization. Fourier Series, DFT, inverse of DFT. Biometric system, identification and verification. FAR/FRR, system design issues. Positive/negative identification. Biometric system security, authentication protocols, matching score distribution, ROC curve, DET curve, FAR/FRR curve. Expected overall error, EER, biometric myths and misrepresentations. Selection of suitable biometric. Biometric attributes, Zephyr charts, types of multi biometrics. Verification on multimodel system, normalization strategy, Fusion methods, Multimodel identification. Biometric system security, Biometric system vulnerabilities, circumvention, covert acquisition, quality control, template generation, interoperability, data storage. Recognition systems: Face, Signature, Fingerprint, Ear, Iris etc. Case studies.
CC-9014	Human-Computer Interaction
	HCI foundation and history; Usability life cycle and methods; Design rules and guidelines; Empirical research methods; Models in HCI - GOMS, Fitts' law and Hick-Hyman's law; Task analysis; Dialogue design; Cognitive architecture and HCI ; Graphic User Interfaces & aesthetics; Usability Testing; UML,OOP,OOM; Design Case Studies.
CC-9015	Indexing and Searching Techniques in Databases
	Database queries and errors in query retrieval algorithms, Memory and disk accesses, Vector and metric spaces, Distance functions, Hashing techniques, One-dimensional orderings, Binary search trees, B-trees and B+-trees, Low-dimensional memory-based index structures, Disk-based index structures, Analysis of high-dimensional index structures, File-based techniques, Dimensionality reduction techniques, Data representation techniques, Multi-attribute retrieval techniques, Joins, skyline queries, XML queries, spatio-temporal queries, Case studies.
CC-9016	Natural Language Processing
	Sound : Biology of Speech Processing; Place and Manner of Articulation; Word Boundary Detection; Argmax based computations; HMM and Speech Recognition.

	<p>Words and Word Forms : Morphology fundamentals; Morphological Diversity of Indian Languages; Morphology Paradigms; Finite State Machine Based Morphology; Automatic Morphology Learning; Shallow Parsing; Named Entities; Maximum Entropy Models; Random Fields. Structures : Theories of Parsing, Parsing Algorithms; Robust and Scalable Parsing on Noisy Text as in Web documents; Hybrid of Rule Based and Probabilistic Parsing; Scope Ambiguity and Attachment Ambiguity resolution. Meaning : Lexical Knowledge Networks, Wordnet Theory; Indian Language Wordnets and Multilingual Dictionaries; Semantic Roles; Word Sense Disambiguation; WSD and Multilinguality; Metaphors; Coreferences. Web 2.0 Applications : Sentiment Analysis; Text Entailment; Robust and Scalable Machine Translation; Question Answering in Multilingual Setting; Cross Lingual Information Retrieval (CLIR).</p>
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Annexure - 1
Reference Books

CC-1001	<p>High Performance Computing, Kevin Dowd An Introduction to High-performance Scientific Computing, Lloyd Dudley Fosdick High Performance and Cloud Computing in Scientific Research and Education, Marijana D, Veljko M, Aleksandar B.</p>
CC-1002	<p>Computer Vision: A Modern Approach by David Forsyth and Jean Ponce Computer Vision: Algorithms and Applications by Richard Szeliski's Computer Vision: Detection, Recognition and Reconstruction</p>
CC-1003	<p>The Design and Analysis of Algorithms, AV Aho, JE Hopcroft and JD Ullman Introduction to Algorithms, T Cormen, C E Leiserson, R L Rivest and C Stein Algorithm Design - Foundations, Analysis & Internet Examples, Michael T. G & Roberto T</p>
CC-2001	<p>A Handbook of Software and Systems Engineering: Empirical Observations, Laws, and Theories, Albert Endres, Dieter Rombach Professional Software Development: Shorter Schedules, Higher Quality Products, More Successful Projects, Enhanced Careers, Steve McConnell Reuse-Based Software Engineering: Techniques, Organizations,&Controls, Hafedh Mili et al.</p>
CC-2002	<p>Database Design, Ryan Stephens, Ronald Plew Conceptual database design: an entity-relationship approach, Carlo B, Stefano C, Sham N Principles of Database Design: Logical organizations, S. Bing Yao</p>
CC-9011	<p>Computer Organization and Design: The Hardware/Software Interface, D. Patterson and J. Hennessy Computer Organization, V. C. Hamacher, Z. G. Vrasenic, and S. G. Zaky The Principles of Computer Organization, Gary Michael Schneider</p>
CC-9012	<p>Programming and Data Structures, Ashok Kamthane Data structures, S. Lipschutz, Data structures using C and C++, Y. Langsam, M.J. Augenstein, A.M. Tanenbaum,</p>
CC-9013	<p>Biometrics: Identity Assurance in the Information Age, John D. Woodward Jr. Biometrics: Advanced Identity Verification: The Complete Guide, Julian Ashbourn Biometrics: Identity Verification in a Networked World, Samir Nanavati</p>

CC-9014	<p>Dix A., Finlay J., Abowd G. D. and Beale R. Human Computer Interaction, 3rd edition, Pearson Education, 2005.</p> <p>Preece J., Rogers Y., Sharp H., Baniyon D., Holland S. and Carey T. Human Computer Interaction, Addison-Wesley, 1994.</p> <p>B. Shneiderman; Designing the User Interface, Addison Wesley 2000 (Indian Reprint).</p>
CC-9015	<p>Foundations of Multidimensional and Metric Data Structures by Hanan Samet, Morgan Kaufmann Publishers, 2005.</p> <p>Introduction to Algorithms by Cormen, Leiserson, Rivest, Stein. Prentice Hall.</p> <p>Research Articles from various journals.</p>
CC-9016	<p>Allen, James, Natural Language Understanding, Second Edition, Benjamin/Cumming, 1995.</p> <p>Charniack, Eugene, Statistical Language Learning, MIT Press, 1993.</p> <p>Jurafsky, Dan and Martin, James, Speech and Language Processing, Second Edition, Prentice Hall, 2008.</p> <p>Manning, Christopher and Heinrich, Schutze, Foundations of Statistical Natural Language Processing, MIT Press, 1999.</p>