Approved on 15-03-2012

Scheme of Study for Master of Science in Computer Science MS (CS)

2-year programme (4 semesters)

#	Category	# of Courses	Credit Hours
1	**Computer Science Courses**	**8**	**24**
	CS Core Courses (CS-Core)	4	12
	CS Elective Courses (CS-Elec)	4	12
2	**Thesis**	**1**	**9**
	Total	**9**	**33**

Semester-I: (12 Credit Hours)

#	*Course Code*	*Category*	*Course Title*	*Credit Hours*	*Prerequisites*
1	CS 501	CS-Core	Advanced Computer Architecture	3 (3,0)	Computer Architecture
2	CS 503	CS-Core	Advanced Algorithm Analysis	3 (3,0)	Data Structures and Algorithms
3	CS 505	CS-Core	Advanced Operating Systems	3 (3,0)	Operating Systems
4	CS 507	CS-Core	Theory of Computation	3 (3,0)	

Semester-II: (9 Credit Hours)

#	*Course Code*	*Category*	*Course Title*	*Credit Hours*	*Prerequisites*
1	CS 502	CS-Elec	CS Elective-1	3	
2	CS 504	CS-Elec	CS Elective-2	3	
3	CS 506	CS-Elec	CS Elective-3	3	

Semester-III: (6 Credit Hours)

#	*Course Code*	*Category*	*Course Title*	*Credit Hours*	*Prerequisites*
1	CS 601	CS-Elec	CS Elective-4	3	
2	CS 603	Thesis	Thesis (partial registration)	3 (0,3)	

Semester-IV: (6 Credit Hours)

#	*Course Code*	*Category*	*Course Title*	*Credit Hours*	*Prerequisites*
1	CS 603	Thesis	Thesis (partial registration)	6 (0,6)	

Electives for MS(CS) with Specialization Areas
(Non-Exhaustive List)

#	*Specialization Area*	*Course Title*	*Credits*
1	Software Engineering	Topics in Software Engineering	3 (3,0)
		Software Engineering and Formal Specifications	3 (3,0)
		Software Quality Assurance	3 (3,0)
		Requirements Engineering	3 (3,0)
		Software Process Improvements	3 (3,0)
2	Artificial Intelligence	Decision Support Systems	3 (3,0)
		Neural Networks	3 (3,0)
		Machine Learning	3 (3,0)
		Natural Language Processing	3 (3,0)
		Agent-Based Computing	3 (3,0)
		Genetic Algorithms	3 (3,0)
3	Information Management	Topics in DBMS	3 (3,0)
		Data Mining	3 (3,0)
		Data Warehousing	3 (3,0)
		Advanced DBMS	3 (3,0)
		Distributed Databases and Data Grids	3 (3,0)
		Digital Libraries	3 (3,0)
4	Human Computer Interaction	Intelligent User Interfaces	3 (3,0)
		Information Retrieval Systems	3 (3,0)
		Interactive Systems Development	3 (3,0)
5	Computer Networks	Topics in Computer Networking	3 (3,0)
		Network Performance Evaluation	3 (3,0)
		Network Programming using Java	3 (3,0)
		Advanced Networking	3 (3,0)
		Parallel and Distributed Computing	3 (3,0)
		Cluster Computing	3 (3,0)
		Client-Server Computing	3 (3,0)
		Network Security	3 (3,0)
6	Programming Language Design and Translators	Theory of Programming Languages	3 (3,0)
		Advanced Compiler Design	3 (3,0)
		Topics in Programming Languages and Translators	3 (3,0)
7	Grid and Cloud Computing	Grid Computing and Data Grids	3 (3,0)
		Cloud Computing	3 (3,0)
		Autonomous Computing	3 (3,0)
		Semantic Grid	3 (3,0)
		Utility Computing	3 (3,0)
		Middleware Technologies	3 (3,0)

Detailed Courses Outline for MS (CS)

Description of CS-Core Courses

Course Name: Advanced Computer Architecture
Course Structure: Lectures:3 Labs: 0 **Credit Hours:** 3
Prerequisite: Computer Architecture
Objective: To develop a thorough understanding of high-performance computer architecture, as a foundation for advanced work in computer architecture.
Course Outlines: This course is aimed at the hardware aspects of parallel computer architectures including the design and protocols evaluation for memory coherence, inter-connection networks and system scalability. Advanced topics in this course will cover multiprocessors on a chip, reconfigurable computing and power aware designs. Evaluation Methodology/metrics. Instruction Set Design. Advanced Pipelining. Instruction-level Parallelism. Prediction-based techniques. Various coarse-grained and fine-grained architectures with reference to SIMD and MIMD designs.
Text book/Reference Books:

1. "Computer Architecture: A Quantitative Approach" (3rd Edition), John L. Hennessy and David A. Patterson, Morgan Kaufmann Publishers, 2002.
2. "Advanced Computer Architecture: A Design Space Approach", Dezso Sima, Terence Fountain, Peter Kacsuk, Addison-Wesley Publishers, 1997.
3. "Scalable Parallel Computing Technology, Architecture, Programming", Kai Hwang, Zhiwei Xu, McGraw Hill Publishers, 1998.

Course Name: Advanced Algorithm Analysis
Course Structure: Lectures: 3 Labs: 0 **Credit Hours:** 3
Prerequisite: Data Structures and Algorithms
Course Outline: Advanced algorithm analysis including the introduction of formal techniques and the underlying mathematical theory. NP-completeness. Search Techniques. Randomized Algorithms. Heuristic and Approximation Algorithms. Topics include asymptotic analysis of upper and average complexity bounds using big-O, little-o, and theta notation. Fundamental algorithmic strategies (brute-force, greedy, divide-and-conquer, backtracking, branch-and-bound, pattern matching, and numerical approximations) are covered. Also included are standard graph and tree algorithms. Additional topics include standard complexity classes, time and space tradeoffs in algorithms, using recurrence relations to analyze recursive algorithms, non-computable functions, the halting problem, and the implications of non-computability. Algorithmic animation is used to reinforce theoretical results. Upon completion of the course, students should be able to explain the mathematical concepts used in describing the complexity of an algorithm, and select and apply algorithms appropriate to a particular situation.
Text Book/Reference Books:

1. Approximation Algorithms, By Vijay V. Vazirani, Springer, 2004.
2. Introduction to Algorithms, By Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest, Clifford Stein, 2nd edition, Published by MIT Press, 2001.
3. Algorithms and Theory of Computation Handbook, By Mikhail J. Atallah Contributor Mikhail J. Atallah, CRC Press, 1998.

Course Name: Advanced Operating System
Course Structure: Lectures:3 Labs: 0 **Credit Hours:** 3
Prerequisite: Operating Systems
Objective: To apprise the students with characteristics of modern operating systems and architectural models.

Course Outline: Introduction; Characterization of Modern Operating Systems; file systems, memory management techniques, Process scheduling and resource management, System Models: Architectural models; Interprocess Communication; Issues of Security in Distributed Systems (Partial coverage); Distributed File System; Concurrency Control in Distributed Systems; Problems of coordination and agreement in Distributed Systems; Replication – Advantages and requirements; Fault-tolerant services; Mobile and Ubiquitous Computing.

Text Book/Reference Books:
1. "Distributed Systems: Concepts and Design" (4th edition), George Coulouris, Jean Dollimore and Kindberg
2. "Distributed Operating Systems: Concepts and Design", Pradeep k. Sinha
3. "Advanced Concepts in Operating Systems", Singhal and Shiviratri

Course Name: Theory of Computation
Course Structure: Lectures: 3 Labs: 0 **Credit Hours**: 3
Course Outline: Automata theory, formal languages, Turing machines, computability theory and reducibility, computational complexity, determinism, non-determinism, time hierarchy, space hierarchy, NP completeness, selected advanced topics.
Text Book/Reference Books:
1. "Introduction to the Theory of Computation" Michael Sipser, PWS Publishing Company.
2. "Computational Complexity", Christos Papadimitriou, Addison-Wesley, 1994.
3. "Introduction to Automata Theory, Languages, and Computation", John Hopcroft and Jeffrey Ullman, Addison-Wesley, 1979. (or latest edition).
4. "Formal models and Computability", Tao Jiang, Ming Li, and Bala Ravikumar, *in Handbook of Computer Science*, CRC Press, 1996.

Description of CS-Elective Courses

Course Name: Topics in Computer Networking
Course Structure: Lectures: 3 Labs: 0 **Credit Hours**: 3
Course Outline: This course offers an advanced introduction and research perspectives in the areas of switch/router architectures, scheduling for best-effort and guaranteed services, QoS mechanisms and architectures, web protocols and applications, network interface design, optical networking, and network economics. The course also includes a research project in computer networking involving literature survey, critical analysis, and finally, an original and novel research contribution. Typical topics can be listed below:
Overview of packet switching networks and devices. Fundamentals of Internet Protocol (IP) networking. Route lookup algorithms. Router architecture and performance. Detailed operation of Internet routing protocols such as Open Shortest Path First (OSPF) and Border Gateway Protocol (BGP). Integrated and differentiated network service models. Traffic Engineering (TE) concepts and mechanisms including label assignment, label distribution, and constraint-based routing algorithms. Multi-protocol label switching and its generalization. Quality of service mechanisms for multimedia and real-time communications. TE-based routing and signaling protocols. Fundamentals of per-flow and aggregate scheduling algorithms. Application-level and network-level signaling protocols for data, voice, and video communications. Resource signaling and resource reservation protocols. Worst-case analysis for multimedia networking.
Text Book/Reference Books:
1. "Switching and Routing", Puzmanov, Addison-Wesley, 2002.
2. "Communication Networks: Fundamentals Concepts and Key Architectures", Garica and Widjaja, McGraw-Hill, 2001.
3. "Computer Networking: A Systems Approach" (3rd Edition), Peterson and Davie, Morgan Kaufman, 2003.
4. "High-Speed Networks: TCP/IP and ATM Design Principles", William Stallings, Prentice Hall; 1998, ISBN: 0135259657.
5. "Computer Networks" (3rd Edition), Andrew S. Tanenbaum, Prentice Hall, March 1996.

Course Name: Advanced Networking
Course Structure: Lectures: 3 Labs: 0 **Credit Hours:** 3
Course Outline: Review of basic concepts: The OSI Model, packet and circuit switching, network topology, ISDN. The TCP/IP protocol stack: IP, ARP, TCP and UDP, DNS, ICMP, Internet Addressing, Routing, IP Multicast, RSVP, Next Generation IP – Ipng, Wireless: Radio basics, Satellite Systems, WAP, current trends, Issues with wireless over TCP. Congestion Control: Control vs. Avoidance., Algorithms, Congestion in the Internet. Mobile IP, Voice over IP (VoIP), VPNs, Network Security. Management: Quality of Service (QoS), network vs. distributed systems management Protocols, web-based management
Text Book/Reference Books:
1. "Computer Networking – A Top-Down Approach Featuring the Internet", James F. Kurose and Keith W. Ross, Addison-Wesley.
2. "Distributed Systems – Concepts and Design", Coulouris, Dollimore, and Kindberg, Addison-Wesley.

3. "Data and Computer Communications", William Stallings, Prentice-Hall.

Course Name: Network Performance Evaluation
Course Structure: Lectures: 3 Labs: 0 **Credit Hours:** 3
Course Outline: This is an advanced course in networks and protocols. Analytical, simulation and experimental methods should be used to evaluate and design networks and protocols. Investigate network management tools and techniques.
Text Book/Reference Books:
1. "Computer Networks and Systems: Queuing Theory and Performance Evaluation" (2^{nd} Edition), T. G. Robertazzi, Springer-Verlag, 1994.

Course Name: Network Security
Course Structure: Lectures: 3 Labs: 0 **Credit Hours:** 3
Course Outline: Introduction; Cryptology and simple cryptosystems; Conventional encryption techniques; Stream and block ciphers; DES; More on Block Ciphers; The Advanced Encryption Standard. Confidentiality & Message authentication: Hash functions; Number theory and algorithm complexity; Public key Encryption. RSA and Discrete Logarithms; Elliptic curves; Digital signatures. Key management schemes; Identification schemes; Dial-up security. E-mail security, PGP, S-MIME; Kerberos and directory authentication. Emerging Internet security standards; SET; SSL and IPsec; VPNs; Firewalls; Viruses; Miscellaneous topics.
Text Book/Reference Books:
1. "Cryptography and Network Security", W. Stallings, Prentice Hall PTR, Upper Saddle River, NJ, 2003.
2. "Network Security: Private Communication in a Public World", Kaufman, R. Perlman, M. Speciner, Prentice Hall PTR, Upper Saddle River, NJ, 2002.
3. "Computer Security: Art and Science", M. Bishop, Addison-Wesley, 2003.
4. "Cryptography: Theory and Practice", Stinson, CRC Press, Boca Raton, FL, 1995.
5. "An Introduction to Cryptography", Richard A. Mollin, Chapman and Hall/CRC, 2001.
6. "Applied Cryptography", B. Schneier, John Wiley and Sons, NY, 1996.
7. "Handbook of Applied Cryptography", A. Menezes, P. Oorshcot, and S. Vanstone, CRC Press, Boca Raton, FL, 1997.
8. "Cryptography and Network Security", Behrouz A. Forouzan.

Course Name: Advanced Compiler Design
Course Structure: Lectures: 3 Labs: 0 **Credit Hours:** 3
Course Outline: An in-depth study of compiler backend design for high-performance architectures. Topics include control-flow and data-flow analysis, classical optimization, instruction scheduling, and register allocation. Advanced topics include memory hierarchy management, optimization for instruction-level parallelism, modulo scheduling, predicated and speculative execution. The class focus is processor-specific compilation techniques, thus familiarity with both computer architecture and compilers is recommended.
Text Book/Reference Books:
1. "Compilers: Principles, Techniques, and Tools", Alfred V. Aho, Ravi Sethi, and Jeffrey D. Ullman, Addison-Wesley, 1988. (or latest edition)

2. “Advanced Compiler Design & Implementation”, Steven S. Muchnick, Morgan Kaufmann, 1997.
3. “Building an Optimizing Compiler”, Robert Morgan, Butterworth-Heinemann, 1998.

Course Name: Intelligent User Interfaces
Course Structure: Lectures: 3 Labs: 0 **Credit Hours:** 3
Course Outline: The increasing complexity of software and the proliferation of information makes intelligent user interfaces increasingly important. The promise of interfaces that are knowledgeable, sensitive to our needs, agile, and genuinely useful has motivated research across the world to advance the state of the art and practice in user interfaces that exhibit intelligence. The text covers the topic well.
Text Book:
1. “Readings in Intelligent User Interfaces”, Mark T. Maybury (Editor), Wolfgang Wahlster (Editor), Paperback - 736 pages, Morgan Kaufman Publishers, April 1998; ISBN: 1558604448.

Course Name: Parallel and Distributed Computing
Course Structure: Lectures: 3 Labs: 0 **Credit Hours:** 3
Course Outlines: Why use parallel and distributed systems? Why not use them? Speedup and Amdahl's Law, Hardware architectures: multiprocessors (shared memory), networks of workstations (distributed memory), clusters (latest variation). Software architectures: threads and shared memory, processes and message passing, distributed shared memory (DSM), distributed shared data (DSD). Possible research and project topics, Parallel Algorithms, Concurrency and synchronization, Data and work partitioning, Common parallelization strategies, Granularity, Load balancing, Examples: parallel search, parallel sorting, etc. Shared-Memory Programming: Threads, Pthreads, Locks and semaphores, Distributed-Memory Programming: Message Passing, MPI, PVM. Other Parallel Programming Systems, Distributed shared memory, Aurora: Scoped behavior and abstract data types, Enterprise: Process templates. Research Topics.
Text Book/Reference Books:
1. “Parallel Programming: Techniques and Applications Using Networked Workstations and Parallel Computers, 1/e”, B. Wilkinson and M. Allen, Prentice Hall, 1999.
2. “Advanced Programming in the Unix Environment”, W. Stevens, Addison-Wesley, 1993.

Course Name: Theory of Programming Languages
Course Structure: Lectures: 3 Labs: 0 **Credit Hours:** 3
Course Outline: Introduction and History, Syntax and Semantics, Control Structures, Types, Logic Programming, Functional Programming and Lambda calculus, Concurrent and Distributed Programming, Dataflow, Object-oriented Programming.
Text Book/Reference Books:
1. “Advanced Programming Language Design”, Raphael Finkel, Addison-Wesley Publisher. ISBN: 0805311912
2. “Introduction to the Theory of Programming Languages”, Bertrand Meyer
3. “The Study of Programming Languages”, Ryan Stansifer

4. “The Anatomy of Programming Languages”, Fischer and Grodzinsky
5. “Concepts of Programming Languages”, Sebesta

Course Name: Computer Vision
Course Structure: Lectures: 3 Labs: 0 **Credit Hours:** 3
Prerequisite: Data Structures and Algorithms
Objectives: By the end of this course Students will be able to explain the concepts behind computer based recognition and the extraction of features from raster images. Students will also be able to illustrate some successful applications of vision systems and will be able to identify the vision systems limitations.
Course Outline: Concepts behind computer-based recognition and extraction of features from raster images. Applications of vision systems and their limitations. Overview of early, intermediate and high level vision, Segmentation: region splitting and merging; quadtree structures for segmentation; mean and variance pyramids; computing the first and second derivatives of images using the isotropic, Sobel and Laplacian operators; grouping edge points into straight lines by means of the Hough transform; limitations of the Hough transform; parameterisation of conic sections. Perceptual grouping: failure of the Hough transform; perceptual criteria; improved Hough transform with perceptual features; grouping line segments into curves. Overview of mammalian vision: experimental results of Hubel and Weisel; analogy to edge point detection and Hough transform; Relaxation labeling of images: detection of image features; Grouping of contours and straight lines into higher order features such as vertices and facets. Depth measurement in images.
Text Book/Reference Books:
1. “Computer Vision: A Modern Approach”, David Forsyth, Jean Ponce, Prentice-Hall, 2003.
2. “Computer Vision”, Linda G. Shapiro and George C. Stockman, Prentice-Hall, 2001.
3. “Handbook of Mathematical Models in Computer Vision”, Nikos Paragios, Yunmei Chen, Olivier Faugeras, and Birkhäuser, 2006.