Master of Science
in
Computer Engineering

2017

PREFACE

The demand on higher education in the field of Computer Engineering (CpE) has witnessed a tremendous increase in the Hashemite Kingdom of Jordan as well as worldwide. This demand has been the main driving force behind the continuous increase in competition among educational institutes to attract IT professionals from all over the globe. This tight global competition has resulted in a severe shortage of IT professionals in the local educational institutions, particularly qualified instructors and faculty members.

As a contribution to the remedy of the current situation, the department of computer engineering is offering its Master of Science program. Our graduates will help JUST, as well as other Jordanian and regional universities, finding high standard staff who are equipped with professional skills and knowledge in the domain.

The proposed program is designed to

- Deliver a solid curriculum in computer engineering, which conforms to guidelines laid down by the College of Graduate Studies at Jordan University of Science And Technology.
- Offer the graduate student some sort of flexibility in choosing his/her line of knowledge by increasing the number of elective courses.
- Supply our local industries and educational systems with qualified IT educationalists.
- Emphasize the significance of conducting applied research that has direct impact on the concerns and needs of the local community.
- Prepare qualified candidates for further higher education opportunities.
- Establish collaborative links and joint research programs with other departments inside and outside the university.

MINIMUM ADMISSION REQUIREMENTS

Applicants to the master's program in Computer Engineering should comply with the rules and regulations of the master's program issued by the Dean's council in 1997, resolution number 606/97.

THESIS OPTION CURRICULUM

This option requires successfully defending a 9-credit master thesis that complies with the University's guidelines plus the completion of 25 credit hours of graduate course work. These 34 credit hours are distributed as follows:

- 16 credit hours of core course work.
- 9 credit hours of electives with advisor approval. 3 credit hours of these electives can be taken from outside the department.
- 9 credit hours of thesis work.

The prerequisite information for all CpE graduate courses will be resolved on a case-by-case basis (for each candidate) upon the decision of the CpE Department Board.

A) Core Courses for the Thesis Option (16 Credit hours)

Course Code	Course Name	Credits
CPE 716	Modeling and Performance Evaluation	3
CPE 745	Parallel Computing	3
CPE 748	VLSI Design	3
CPE 766	System Software and Design	3
CPE 771	Computer Networks and Security	3
CPE 780	Seminar in Computer Engineering	1

B) Elective Courses for the Thesis Option (9 Credit hours).

Course Code	Course Name	Credits
CPE 712	Computational Graph Theory	3
CPE 718	Network Flows	3
CPE 720	Linear Programming	3
CPE 740	Advanced Computer Architecture	3
CPE 742	Distributed Systems	3
CPE 746	Embedded Real-Time Systems	3
CPE 749	Fault Tolerant Digital Systems	3
CPE 750	Digital Image Processing	3

CPE 751	Artificial Intelligence and Machine Learning	3
CPE 752	Computer Vision	3
CPE 754	Neural Networks and Deep Learning	3
CPE 756	Fuzzy Systems	3
CPE 759	Robotics	3
CPE 760	Advanced Operating Systems	3
CPE 761	Compiler Structures	3
CPE 763	Advanced Algorithms and Data Structures	3
CPE 765	Advanced Software Engineering	3
CPE 772	Multimedia Networking and Communication	3
CPE 773	Storage Structures	3
CPE 774	Advanced Internet Systems	3
CPE 779	Special Topics in Computer Engineering	3

C) Thesis (9 Credit hours)

Course Code	Course Name	Credits
CPE 799a	Master's Thesis	9
CPE 799b	Master's Thesis	6
CPE 799c	Master's Thesis	3
CPE 799d	Master's Thesis	0

WORK PLAN (THESIS OPTION)

The recommended study plan for the thesis option is summarized in the subsequent tables. Although the thesis is registered in the last semester, it is highly recommended that master students start working and discussing the thesis topic with faculty members ahead of time. Developing a successful thesis usually requires more than two semesters.

First semester / First year

Course Code	Course Name	Credits
CPE 716	Modeling and Performance Evaluation	3
CPE 745	Parallel Computing	3
CPE 780	Seminar in Computer Engineering	1
Total		7

Second semester / First year

Course Code	Course Name	Credits
CPE 748	VLSI Design	3
CPE 771	Computer Networks and Security	3
	Elective Course	3
Total		9

First semester / Second year

Course Code	Course Name	Credits
CPE 766	System Software and Design	3
	Elective course	3
	Elective course	3
Total		9

Second semester / Second year

Course Code	Course Name	Credits
CPE 799a	Master's Thesis	9
Total		9

NON-THESIS OPTION

This option requires the completion of 34 credit hours of graduate course work and passing a comprehensive examination.

The 34 credit hours of required graduate course work are distributed as follows:

- 19 credit hours of core course work.
- 15 credit hours of electives courses. Up to 6 credit hours of electives courses can be taken from outside the department upon the approval of the department graduate committee.

A) Core Courses for the Non-Thesis Option (19 Credit hours)

Course Code	Course Name	Credits
CPE 716	Modeling and Performance Evaluation	3
CPE 745	Parallel Computing	3
CPE 748	VLSI Design	3
CPE 763	Advanced Algorithms and Data Structures	3
CPE 766	System Software and Design	3
CPE 771	Computer Networks and Security	3
CPE 780	Seminar in Computer Engineering	1

B) Elective Courses for the Non-Thesis Option (15 Credit Hours)

Course Code	Course Name	Credits
CPE 712	Computational Graph Theory	3
CPE 718	Network Flows	3
CPE 720	Linear Programming	3
CPE 740	Advanced Computer Architecture	3
CPE 742	Distributed Systems	3
CPE 746	Embedded Real-Time Systems	3
CPE 749	Fault Tolerant Digital Systems	3
CPE 750	Digital Image Processing	3
CPE 751	Artificial Intelligence and Machine Learning	3
CPE 752	Computer Vision	3

CPE 754	Neural Networks and Deep Learning	3
CPE 756	Fuzzy Systems	3
CPE 759	Robotics	3
CPE 760	Advanced Operating Systems	3
CPE 761	Compiler Structures	3
CPE 765	Advanced Software Engineering	3
CPE 772	Multimedia Networking and Communication	3
CPE 773	Storage Structures	3
CPE 774	Advanced Internet Systems	3
CPE 779	Special Topics in Computer Engineering	3

C) Passing the Comprehensive Exam (CPE 798).

WORK PLAN (NON-THESIS OPTION)

First semester / First year

Course Code	Course Name	Credits
CPE 716	Modeling and Performance Evaluation	3
CPE 745	Parallel Computing	3
CPE 780	Seminar in Computer Engineering	1
Total		7

Second semester / First year

Course Code	Course Name	Credits
CPE 748	VLSI Design	3
CPE 771	Computer Networks and Security	3
	Elective Course	3
Total		9

First semester / Second year

Course Code	Course Name	Credits
CPE 763	Advanced Algorithms and Data Structures	3
CPE 766	System Software and Design	3
	Elective Course	3
Total		9

Second semester / Second year

Course Code	Course Name	Credits
	Elective Course	3
	Elective Course	3
	Elective Course	3
Total		9

CPE 712 Computational Graph Theory 3C

Review of basic results in graph theory. Complexity measures of algorithms. Basic algorithms: Depth-first search, breadth-first search, biconnectivity, strong connectivity, minimum spanning tree, shortest paths, transitive closure and optimum branching. Efficient algorithms for the maximum flow problem. Vertex and edge connectivity: Manager's theorems, connectivity testing algorithms based on network flow theory. Matchings: Hall's theorem, and the alternating chain theorems. Maximum matching algorithms for general and bipartite graphs. Algorithms for weighted matchings. Set manipulation algorithms and applications. Reducibility and dominators in program graphs. NP-complete graph problems and approximation algorithms.

CPE 716 Modeling and Performance Evaluation 3C

This course provides the fundamental techniques of modeling and performance evaluation of computer systems. The course covers Markov chain theory, queuing theory, simulation models, analytical modeling, workload characterization, and performance evaluation problems.

CPE 718 Network flows 3C

Formulation and solution of deterministic network flow problems including shortest path, minimum cost flow, and maximum flow. Network and graph formulations of combinatorial problems including assignment, matching, and spanning trees.

CPE 720 Linear Programming 3C

This course introduces methods of optimization to engineering students, including linear programming, network flow algorithms, integer programming, interior point methods, quadratic programming, nonlinear programming, and heuristic methods. Numerous applications are presented in the domain of engineering. The goal is to maintain a balance between theory, numerical computation, problem setup for solution by optimization software, and applications to engineering systems.

CPE 740 Advanced Computer Architecture 3C

Principles of modern high performance computer and micro architecture: static vs. dynamic issues, pipelining, control and data hazards, branch prediction and correlation, cache structure and policies, RISC, CISC, superscalar processors. Cost, performance and physical complexity analyses.

CPE 742 Distributed Systems 3C

Fundamental design: naming, synchronization, latency, and bandwidth. Architectural evolution and technological driving forces. Parallel programming models, communication primitives, programming and compilation techniques, multiprogramming workloads and methodology for quantitative evaluation. Latency avoidance through replication in small-scale and large-scale shared memory designs; cache-coherency, protocols, directories, and memory consistency models. Message passing: protocols, storage management, and deadlock. Efficient network interface, protection, events, active messages, and coprocessors in large-scale

designs. Latency tolerance through prefetching, multithreading, dynamic instruction scheduling, and software techniques. Network design: topology, packaging, k-ary n-cubes, performance under contention. Synchronization: global operations, mutual exclusion, and events. Alternative architectures: dataflow, SIMD, systolic arrays.

CPE 745 Parallel Computing 3C

This course provides advanced topics in parallel computing. Topics include: Moore's law, Flynn's taxonomy, instruction-level parallelism, architectural support for shared memory, cache coherence, distributed memory, multi-processor, multi-core programming, thread programming, thread safety, synchronization, message passing, MPI-based parallel systems, distributed file systems, virtualization, cluster-based systems, cloud computing, MapReduce/Hadoop, and overview of modern parallel systems such as Spark, GPU, CUDA, and NoSQL.

CPE 746 Embedded Real-Time Systems 3C

Designing embedded real-time computer systems. Types of real-time systems, including foreground/background, non-preemptive multitasking, and priority-based pre-emptive multitasking systems. Soft vs. hard real time systems. Task scheduling algorithms and deterministic behavior. Ask synchronization: semaphores, mailboxes and message queues. Robust memory management schemes. Application and design of a real-time kernel.

CPE 748 **VLSI Systems** **3C**

CMOS circuits, clocking strategies, sequential circuits, CMOS process flows, design rules, structured layout techniques, dynamic circuits, performance analysis, design optimization, device sizing, CMOS arithmetic login units, high speed carry chains, fast CMOS multipliers, CMOS memory cells, array structures, Design for testability, VLSI case studies.

CPE 749 **Fault Tolerant Digital Systems** **3C**

Fault-tolerant digital system theory and practice, recent and classic fault-tolerant techniques based on hardware redundancy, time redundancy, information redundancy, software redundancy, hardware and software reliability analysis, and examples of fault-tolerant designs.

CPE 750 **Digital Image Processing** **3C**

Physical descriptions of continuous images; properties of the human visual system; sampling and quantization of images; matrix representation of image forming and image processing systems; unitary transforms; image compression enhancement, scene matching and recognition, and applications. Demonstrations. Students write image processing algorithms.

CPE 751 **Artificial Intelligence and Machine Learning** **3C**

Study of automated reasoning; representing change and the effects of actions; problem solving and planning. The course includes the development of working programs that search, reason, and plan intelligently. Controlling physical mobile robot systems that operate in dynamic and unpredictable environments is covered. Building smart

embedded chips for machine learning.

CPE 752 **Computer Vision** **3C**

Introduces the principles and the fundamental techniques of Computer Vision. Topics include programming aspects of vision, image formation and representation, multi-scale analysis, boundary detection, texture analysis, shape from shading, object modeling, stereo-vision, motion and optical flow, shape description and objects recognition (classification), and hardware design of video cards. AI techniques for Computer Vision are also covered.

CPE 754 **Neural Networks and Deep Learning** **3C**

Adaptive threshold elements, feed forward layered networks, back propagation, optimal decision making, SVM. Shallow and deep NN, deep learning, convolutional networks, recurrent networks. Experimental and theoretical applications of neural networks to pattern recognition, speech recognition, face recognition, and self-learning adaptive control systems.

CPE 756 **Fuzzy Systems** **3C**

Fuzzy sets and basic operation, further operations on fuzzy sets, fuzzy relations and the extension principle, fuzzy arithmetic, linguistic variables and fuzzy-IF-THEN rules, fuzzy logic and approximate reasoning, fuzzy rule base and inference engine. Fuzzy logic in control engineering, fuzzy and AI, fuzzy and pattern recognition, fuzzy modeling.

CPE 759 **Robotics** **3C**

Introduction to robotic systems. Mechanical manipulators, kinematics, manipulator

positioning and path planning. Dynamics of manipulators. Robot motion programming, and control algorithm design, Robotic vision, sensing and the programming of robots.

CPE 760 Advanced Operating Systems 3C

Process Management: process concepts; asynchronous concurrent processes; deadlock and indefinite postponement; Storage Management: real storage; virtual storage organization; virtual storage management; Process Management: job and processor scheduling; Auxiliary Storage Management: disk performance optimization; Review of multiprogramming operating systems including process distributed memory multiprocessors and distributed systems. Topics include distributed file systems, concurrency, and distributed process coordination. Introduction to network communication issues and special purpose systems such as real time systems, transaction processing systems, and client-server technology. Network Operating Systems (NOS); Distributed Operating Systems (DOS).

CPE 761 Compiler Structure 3C

This course covers translators and interpreters for programming languages, syntax of programming languages; syntax directed compilation; parsing techniques such as operator precedence, top down, bottom up and reductive strategies; generation and optimization of machine code; error handling: detection and correction; the run time environment and storage allocation.

CPE 763 Advanced Algorithms and Data Structures **3C**

Design and analysis of noncommercial problems involving sorting, searching, scheduling, graph theory, and geometry. Design techniques such as approximation, branch-and-bound, divide-and-conquer, dynamic programming, greed, and randomization applied to polynomial and NP-hard problems. Analysis and space utilization. Implementation of algorithms is based on advanced data representation techniques and object oriented modeling.

CPE 765 Advanced Software Engineering **3C**

Project management, software tools, requirements and specification methods; top-down, bottom-up, and data-flow design. Structured programming, information hiding, programming language issues, and coding standards. Software development environments, fault tolerance principles, and testing. Software reliability; engineering real-time systems; managing large software projects; resource estimation; validation and verification.

CPE 766 System Software and Design **3C**

This course aims to provide the fundamentals of what a system should do and how the components of the system should be implemented to work together. This course deals with theory, methods and techniques needed to develop complex information systems applicable to a given architectural design model. Topics covered are: system characteristics, managing

projects, prototyping, tools, phases in systems development life cycle, managing and organizing resources, and Object-Oriented (OO) techniques.

CPE 770 Advanced Computer Networks 3C

Network technologies: packet switching, cell switching, optical networks. Switching and routing: packet switch architectures, ATM switch architectures, Internet routers and their performance. End systems: network interface design, operating system support for high performance, protocol processing. Network control: traffic management, congestion (flow and rate) control, admission control. Applications demanding of high-speed communication.

CPE 771 Computer Networks and Security 3C

This course covers theoretical and applied topics in network and security. It focuses on the latest network and security issues. This course explores the state-of-art topics in advanced routing algorithms, advanced network congestion control algorithms, quality of service, VPN networks, mobile networks, sensor networks, advanced cryptography, security protocols, firewalls, intrusion detection and prevention systems, vulnerability assessment, and other security technologies.

CPE 772 Multimedia Networking and Communication 3C

Multimedia applications and requirements, multimedia traffic generation and characterization: audio compression, image and video compression standards (JPEG, H.261, MPEG-2 and H.263). Modern

networking technologies and protocols for multimedia applications: LAN technologies; home broadband services including ADSL, cable modems (IEEE 802.14), and Hybrid Fiber-Coax (HFC); Internet protocols including IP multicast, resource reservation protocols (ST2+, RSVP); ATM services and applications. Integrated services in the Internet: network element, controlled load, and guaranteed QoS service specifications. Integrated services over specific link layers (ISSLL). Real-time transport protocol (RTP), RTP profiles and payloads. Audio-Video conferencing standards: the Internet architecture (SDP, SAP, SIP); ITU recommendations H. 320 and H.323. Data conferencing standards: ITU recommendation T.120. Real-time streaming protocol (RTSP).

CPE 773 Storage Structures **3C**

Introduces the network storage landscape, data flood and fluid data, data storage on open systems servers. SCSI systems servers and their limitations, volume managers and device drivers, software mirroring over LAN and WAN, cashes in storage networks are covered. We investigate boosting availability and performance with RAID and disk subsystems. SAN design, building better backup systems with SANs, fiber channel networking technology for storage networks (point-to-point, loop, fabrics), distributed intelligence data sharing in the SAN, plug and play storage with NAS are also covered. Applications include comparison of SAN and NAS technologies, mapping SCSI-3 (FCP), IP, VIA, HIPPI, IEEE 802.2, 802.3, 803.5, SBCCS, AAL5 of ATM and FICON

protocols to fiber channels. Laboratories include the usage of SAN protocols at the hardware and software levels.

CPE 774 Advanced Internet Systems 3C

HTTP, XML, ICE and W3C standards. Design of web spiders, exploration, indexing and scalable search engine query processing. Information retrieval, TF/IDF, latent semantic indexing, hypertext link analysis, result clustering. Website management, information integration, e-commerce, personalization, collaborative filtering, security and privacy. Case studies: Alta vista, Google, Ask Jeeves, Jango, Vignette, Strudel, Amazon, Webwatcher.

CPE 779 Special Topics in Computer Engineering 3C

CPE 780 Seminar in Computer Engineering 1C

CPE 785 Special Topics in Computer Engineering 3C

A specific topic in computer engineering is selected by the instructor and taught in depth in class.

CPE 798 Comprehensive Exam 0C

This course consists of a comprehensive exam that covers the course work taken by the student. The exam takes place in the department and is administered by a number of specialized faculty members.

CPE 799a Master's Thesis 9C

CPE 799b Master's Thesis 6C

CPE 799c Master's Thesis 3C

CPE 799d Master's Thesis 0C