King Fahd University of Petroleum & Minerals
College of Computer Science and Engineering
Information and Computer Science Department

Master of Science in Computer Science

Student Guide

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Revision History

Date	Version	Description	Author
2019-01-24	1.0	Guide created	S. Zhioua
2019-08-25	1.1	Unify all ICS graduate guides	M. Alshayeb
2020-10-25	1.1.1	Add missing course descriptions	M. Alshayeb

Table of Content

1. Introduction

Computer science is an enormously vibrant field. From its inception over half a century ago, computer science has become the defining technology of our age. Computers are integral to modern culture and are the primary engine behind much of the world's economic growth. The field, moreover, continues to evolve at an astonishing pace. New technologies are introduced continually, and existing ones become obsolete in the space of a few years.

The Department of Information and Computer Science offers Master of Computer Science (M.Sc. CS) degree, which is in compliance with the international standards and recommendations.

2. ICS Department Vision and Mission

The vision of the ICS Department is to be a **regional leader that is recognized worldwide in education, research and professional development in the areas of Computer Science and Software Engineering.** The mission of the Department of Information and Computer Science is to:

1. Provide high quality undergraduate and graduate educational programs in the fields of Computer Science and Software Engineering.
2. Contribute significantly to the research and the discovery of new knowledge and methods in computing.
3. Offer expertise, resources, and services to the community.
4. Keep its faculty members current by providing opportunities for professional development.

3. Program Educational Objectives and Outcomes

3.1 Program Educational Objectives

In line of the vision and mission of the ICS Department, the objectives of the MS.CS Program are to:

1. Produce specialized computer science expertise through which advanced technologies and their applications can be enhanced, transferred, and utilized in the Kingdom and possibly elsewhere.
2. Produce researchers who can investigate problems in different application domains and creatively develop and evaluate computational solutions.
3. Equip graduates with a strong foundation for further research and discovery work.
4. Develop effective communication and collaboration skills as researchers who can document and publish their work in reputable journals and conferences.

3.2 Program Learning Outcomes

Upon completion of the program, a graduate of the MS.CS program will:

a. Have a breadth of knowledge in different current and advanced computer science topics.
b. Use appropriate tools and variety of sources to evaluate multiple points of view for analyzing and integrating information to conduct critical reasoned arguments.
c. Be capable of self-learning and comprehending emerging scientific and engineering trends in order to be able to propose specific improvements.
d. Have the scientific and technical knowledge and skills necessary to allow identifying pertinent computing problems and formulate corresponding research plans to

develop and evaluate computations techniques and models to solve problems in any related discipline.

e. Be able to apply subject matter knowledge in a range of contexts to solve problems and make decisions.
f. Be able to communicate and present research outcomes to a range of audience both orally and in writing.
g. Be able to choose ethical courses of action in research and practice.

4. Program Requirements

All students enrolled in the MS.CS program are required to complete 30 credit hours that include 24-credit hours of coursework, 6-credit hours of thesis, and a seminar course (0 credit). The coursework requirements are broken down into core coursework requirements and elective coursework requirements.

4.1 Course Requirements

4.1.1 Core Courses

- Six (6) credit hours (i.e. 2 courses) of CS core courses:
  - ICS 553: Algorithms and Complexity
  - ICS 535: Theory and Design of Programming Languages
- Three (3) credit hours (i.e. 1 course) of research methods course:
  - ICS 500: Research Methods and Experiment Design in Computing
- 0-credit hours Seminar Course
  - ICS 599: Seminar
- Six (6) credit hours thesis work
  - ICS 610: Master Thesis

4.1.2 CS Elective Courses

- **Major area electives:** Six (6) credit hours (i.e. 2 courses) that must be taken from the major area the student selected (either Area A or Area B):

Area A: Algorithms and Applications	**Area B: Systems and Languages**
ICS 546: Multimedia Information Management ICS 545: Arabic Computing ICS 582: Natural Language Processing ICS 583: Pattern Recognition ICS 547: Digital Image Processing ICS 557: Machine Learning ICS 558: Introduction to Bioinformatics and Biomedicine	ICS 531: Advanced Operating Systems ICS 532: Performance Analysis and Evaluation ICS 533: Modeling and Simulation of Computing Systems ICS 541: Database Design and Implementation
ICS 611: Combinatorial, Approximation and Probabilistic Algorithms ICS 614: Advanced Pattern Recognition ICS 615: Advanced Computer Vision	ICS 630: Distributed Systems ICS 633: Semantics of Programming Languages

- **General electives:** Nine (9) credit-hours (i.e. 3 courses) that can be taken from the following options:
  - Courses from all Areas: A, B, C, and D

- Courses from other programs (SWE and SEC) and courses from other departments (COE, Math, EE, etc.) subject to ICS department approval.
- Condition 1: At least one course should be from outside Areas A and B.
- Condition 2: At least one course should be from Areas C and D.

Area C: Security and Net-centric Computing	**Area D: Software Engineering**
ICS 555: Cryptography and Data Security ICS 570: Computer Communication Network ICS 571: Client Server Programming ICS 572: Distributed Computing ICS 573: High-Performance Computing ICS 575: Application Development for Internet Based Services ICS 576: Concurrent and Parallel Processing COE 541: Local and Metropolitan Area Networks COE 542: High-Speed Networks COE 543: Mobile Computing and Wireless Networks CNW 550: Computer Network Design CNW 554: Modeling and Analysis of Computer Networks CNW 555: Protocol Engineering SEC 511: Principles of Information Assurance and Security SEC 521: Network Security SEC 524: Computer and Network Forensics SEC 528: Security in Wireless Networks SEC 534: Database Security SEC 536: Web Application Security SEC 538: Trusted Computing SEC 544: Biometric Systems SEC 546: Embedded Systems Security SEC 548: Watermarking and Steganography SEC 595: Special Topics in Information Assurance and Security SEC 531: Secure Software	SWE 515: Software Requirements Engineering SWE 516: Software Design SWE 526: Software Testing and Quality Assurance SWE 531: Secure Software SWE 532: Web Applications Security SWE 536: Software Architecture SWE 539: Software Metrics SWE 566: Software Agents SWE 585: Empirical Software Engineering SWE 587: Software Project Management SWE 595: Special Topics in Software Engineering
ICS 654: Advanced Topics in Computer Networking SEC 611: Cryptographic Computations SEC 621: Advanced Network Security SEC 631: Security in Operating Systems and Cloud Computing	SWE 634: Software Reuse SWE 638: Software Maintenance & Re-Engineering SWE 670: Formal Methods and Models in Software Engineering SWE 671: Global Software Engineering

4.2 Degree Plan

First Semester			Second Semester		
Course	Description	CR	Course	Description	CR
ICS 553	Algorithms and Complexity	3	ICS 535	Theory and Design of Programming Languages	3
ICS xxx	Major Area Elective I	3	ICS xxx	Major Area Elective II	3
ICS 500	Research Methods and Experiment Design in Computing	3	XXX xxx	General Elective I	3
	Total	9		Total	9
	Third Semester			Fourth Semester	
Course	Description	CR	Course	Description	CR
ICS 599	Seminar	0	ICS 610	Master Thesis	6
XXX xxx	General Elective II	3			
XXX xxx	General Elective III	3			
ICS 610	Thesis Proposal	0			
	Total	6		Total	6

5. Admission Requirements

The admission process starts with an application to the Deanship of Graduate Studies. The applicant must fill all related forms which can be obtained from the Deanship of Graduate Studies office or website. The applicant must also submit the following:

- A letter of intent
- Graduation certificates
- Transcripts
- At least three reference letters
- Official TOEFL scores report
- General GRE scores report

An MS in CS applicant must have a BS in computer science or a related discipline from a recognized institution whose undergraduate programs are at least comparable to those of KFUPM in both content and quality. All applicants must have a cumulative GPA of at least 3.0 out of 4.0. In order for an applicant to be admitted to the M.Sc. CS program, he must have a strong background in the following core areas of computer science:

- Data Structures
- Computer Architecture
- Algorithms
- Programming Languages
- Database Systems
- Computer Networks
- Operating Systems

Unsatisfactory background in any of these areas is considered a deficiency. Conditional admission may be granted to otherwise qualified students with some core background deficiencies. Students with deficiencies must take the corresponding appropriate course(s)

at KFUPM. Any deficiency must be completed with a grade of B or better before a change of status to regular is realized.

6. Courses Descriptions

6.1 Area A: Algorithms and Applications

ICS 553: Algorithms and Complexity **3-0-3**

Computational complexity: P-space and EXP classes, Reduction, NP-complete problems, Cook's theorem, Randomized algorithms, Approximation algorithms, Branch-and-Bound, Amortized analysis; Max flow, Bipartite matching; Geometric algorithms: Convex hull, Closest pairs; Computability: Turing machines, Church-Turing thesis, Rice's theorem, Undecidability.

Prerequisites: ICS 353 or equivalent

ICS 546: Multimedia Information Management **3-0-3**

Multimedia data representation and management in the context of content-based retrieval, audio, image and video data representation, Information retrieval from text. Content based retrieval of audio, image and video data, Similarity measures. Query formulation and evaluation, Multi-dimensional indexing algorithms and data structures. Multimedia compression. Multimedia data mining.

Prerequisites: Consent of Instructor

ICS 547 Digital Image Processing **3-0-3**

Continuous Image. Mathematical Characterization. Psychovisual Properties. Photometry and Colorimetry. Superposition and Convolution. Image Transforms. Linear Processing Techniques. Image Enhancement. Morphological Image Processing. Edge Detection. Image Feature Extraction. Image Segmentation. Shape Analysis.

Prerequisites: Consent of Instructor

ICS 557 Advanced Machine Learning **3-0-3**

Linear and logistic regression. Regularization. Generalized linear models. Learning theory. Support vector machines. Kernel methods. Principal component analysis. Independent component analysis. Hidden Markov models. Random forests. Design of learning systems. Recommender systems. Online Learning. Ensemble learning models. Bootstrapping techniques.

Prerequisites: ICS 485 or Consent of the Instructor

ICS 558 Introduction to Bioinformatics and Biomedicine **3-0-3**

This course offers an introduction to bioinformatics with an emphasis on biomedical aspects. Topics include bioinformatics databases, sequence alignments, protein domains, protein-protein interaction, gene expression, gene ontology, pathways, disease state analysis, and computational methods in biomedicine. Prerequisites: Consent of the Instructor

ICS 611 Combinatorial, Approximation and Probabilistic Algorithms **3-0-3**

Representation and generation of combinatorial objects, Graph algorithms, Greedy method and the theory of matroids. Graph matching and applications. Network flows and applications. Approximation algorithms to combinatorial problems like scheduling, bin-packing, knapsack, vertex cover, TSP, clique partitioning, graph compression, Steiner problem on networks. Randomized algorithms: Monte-Carlo, Las-Vegas, algorithms,

occupancy problems, randomized sorting and pattern matching, Markov chains and random walks.
Prerequisites: ICS 553 or Consent of the Instructor

ICS 614 Advanced Pattern Recognition 3-0-3
The course covers advanced topics in pattern recognition and machine learning. Recent conference and journal papers will be discussed in depth. Tentative topics: Classification and discriminant analysis, feature generation using transformations. Feature selection, data transformation and dimensionality reduction, Classifier evaluation, Kernel methods, error rate estimation techniques and performance evaluation. Actual topics covered will depend on time available and students' interests.
Prerequisites: ICS 583 or equivalent

ICS 615 Advanced Computer Vision 3-0-3
This course intends to provide an in-depth overview of the current state-of-the-art of computer vision by covering a set of advanced topics that are actively investigated. Recent conference and journal papers will be discussed in depth. Tentative topics: Low level vision: Image Segmentation, Stereo, Optical flow, de-noising and texture analysis; Higher level vision: Object Detection and Recognition/Pose Estimation; geometrical and 3D vision, stereo, 3D scene reconstruction, motion analysis, visual tracking, object recognition and human motion analysis, capturing and recognition. Actual topics covered will depend on time available and students' interests.
Prerequisites: ICS 547 or Consent of the Instructor

6.2 Area B: Systems and Languages

ICS 531 Advanced Operating Systems 3-0-3
Advanced concepts in operating systems design; multiprocessing model, interprocess communication; synchronization mechanisms; resource management and sharing; scheduling in multiprocessor system; Process migration; Operating system-level virtualization; Special-purpose operating systems: Real-time, Distributed and network operating systems; Distributed deadlock handelling; Distributed file system; Distributed shared memory; Replication & consistency; In addition, students will be exposed to recent developments in operating systems through research projects and papers.
Prerequisites: Consent of the Instructor

ICS 532 Performance Analysis & Evaluation (3-0-3)
Performance measures. Modeling methodologies: queuing models, graph models, dataflow models, and Pertinent models. Mathematical models of computer systems: CPU and computer subsystems such as memory and disks. Bottleneck analysis. Modeling multi-server systems. Model validation methods. Case studies. Project(s).
Equivalent to: COE 587
Prerequisite: STAT 319 or Equivalent

ICS 533 Modeling and Simulation of Computing Systems (3-0-3)
Basic probability and statistics. Review of discrete-event simulation tools and methodologies. Simulation languages. Random Number generation. Developing Simulation

Models. Simulation Validation. Output Data Analysis. Applications to computer systems. Project(s).
Equivalent to: COE 588
Prerequisite: STAT 319 or Equivalent

ICS 535 Theory and Design of Programming Languages **3-0-3**

Fundamentals of type systems, type inference, control structures, and storage management. Formal syntax specification. Semantic specification models: axiomatic, operational and denotational. Project(s) to design a programming language.

Prerequisites: ICS 410 or Equivalent

ICS 541 Database Design and Implementation **(3-0-3)**

Database development life cycle. Data modeling. Database design theory. Query processing Concurrency control and transaction management. Recovery. Security. Database applications: data warehousing, data mining, web pages, and others. Various types of database systems: object relational, object-oriented, distributed, client/server, and others. Current trends in database research. Project(s).

Prerequisite: ICS 334 or Equivalent

ICS 630 Distributed Systems **3-0-3**

Taxonomy of distributed systems: Client-server, cluster systems, Grid systems, P2P systems, cloud systems, volunteer-based systems. Distributed systems service models. Modeling, performance, scalability, elasticity and trust/reputation issues in distributed systems. Project(s).

Prerequisites: ICS 531 or Consent of Instructor.

ICS 633 Semantics of Programming Languages **3-0-3**

Formal methods for the description of programming languages. Advanced semantics models, attribute grammar, two-level grammars, fixed-point theory of computation, Program verification techniques.

Prerequisites: ICS 535 or Consent of the Instructor

6.3 Area C: Security and Net-centric Computing

ICS 555 Cryptography and Data Security **3-0-3**

Mathematical principles of cryptography and data security. A detailed study of conventional and modern cryptosystems. Zero knowledge protocols. Information theory, Number theory, Group theory, Complexity Theory concepts and their applications to cryptography.

Prerequisites: Consent of Instructor

ICS 654 Advanced Topics in Computer Networking **3-0-3**

This course explores recent research trends and developments in computer networks and their applications covering state-of-the-art topics and case studies.

Prerequisites: ICS 570 or equivalent

6.4 Area D: Software Engineering

Courses used for this area exist in the current Software Engineering Master's program.

6.5 Common Courses

ICS 500 Research Methods and Experiment Design in Computing **3-0-3**

Integrated treatment to the models and practices of experimental computer science. Topics include scientific methods applied to computing, computational problem/solution characterization, quality metrics and performance estimation of computation systems, uses of analytic and simulation models, design of experiments, interpretation and presentation of experimental results, hypothesis testing, and statistical analyses of data.

Prerequisites: STAT 319 or equivalent

ICS 590 Special Topic in Computer Science I **3-0-3**

Advanced topics selected from current literature that deals with theoretical foundations and advances in computer science. The specific content of an offering of the course should focus on a specific area of computer science.

Prerequisites: Consent of Instructor

ICS 592 Special Topic in Computer Science II **3-0-3**

Advanced topics selected from current literature that deals with theoretical foundations and advances in computer science. The specific content of an offering of the course should focus on a specific area of computer science.

Prerequisites: Consent of Instructor

ICS 599 Seminar **1-0-0**

Graduate students are required to attend the seminars given by faculty members, visiting scholars, and fellow graduate students. Additionally, each student must give at least presentation on a timely research topic. Among other things, this course is designed to give the student an overview of research, research methodology, journals and professional societies.

Graded on a Pass or Fail basis.

Prerequisites: ICS 500

ICS 606 Independent Research **0-0-3**

This course is intended to allow the student to conduct research in advanced problems in his MS research area. The faculty offering the course should submit a research plan to be approved by the Graduate Program Committee at the academic department. The student is expected to deliver a public seminar and a report on his research outcomes at the end of the course.

Graded on a Pass or Fail basis.

Prerequisites: Prior arrangement with an instructor

ICS 610 Master Thesis **0-0-6**

The Student has to undertake and complete a research topic under the supervision of a faculty member in order to probe in depth a specific problem in Computer Science.

Prerequisites: ICS 599