Operational rules of the Master of Science Program

Department of Computer Science, Rutgers – Camden

Jan. 2008

The degree of Master of Science in Computer Science (**MS CS** for short) is targeted to traditional and non-traditional students who want to deepen their knowledge of CS, advance their careers, or possibly prepare for further doctoral studies programs. The courses will be held in the evening.

An accelerated combined BS-MS program for promising undergraduates is also available.

Application deadlines:

Both Fall and Spring admissions are allowed. The **application deadlines** for all application material are:

- Fall admission application deadline: **31 May** (31 March for applicants from abroad).
- Spring admission application deadline: **31 Oct.** (30 Sept. for applicants from abroad).

Applicants wishing to be considered for assistantships, fellowships, or other financial aid may apply for fall term admission only and should submit their applications by March 1 (per University regulation).

Admission requirements

1. Rutgers University requirements:
A bachelor's degree with a grade-point-average of at least 3.0 (i.e., at least a B average).

2. Requirements specific to the MS CS program:

- Substantial background in computer science and in basic mathematics.

Details:

A computer science degree is preferred but not required.

The required computer science background should include:

- programming (the equivalent of the introductory programming sequence 50:198:111, 112, 113, 114),
- data structures (the equivalent of 50:198:213),
- a third-year or higher course in algorithms (the equivalent of 50:198:371),

and fundamentals of computer architecture systems (the equivalent of 50:198:231).

The mathematics background should include:

- discrete mathematics (the equivalent of 50:640:237 or 50:198:171),
- calculus (the equivalent of the calculus sequence 50:640:121, 122, 221),
- as well as probability and statistics (the equivalent of 50:960:283, 284 or 50:960:336).

Applicants with an inadequate background must remove all deficiencies (by taking the equivalent undergraduate courses), before being considered for admission.

- A cumulative undergraduate GPA of at least 3.0 (original transcripts required).
- Satisfactory performance on the GRE General (Aptitude) Test (original reports required).
- Three letters of recommendation (see the Application forms).
- A personal statement (of at most two pages) about academic interests and career goals.
- For applicants whose native language is not English, satisfactory performance on the TOEFL.
- Optionally, other supporting information, such as work or academic experience and special skills.

Admission of **non-matriculated** students:

The program admits non-matriculated students. Admission as a non-matriculated student does not in any way guarantee later admission into the MS CS degree program. Non-matriculated students who later are admitted to the MS CS degree program can use up to 12 non-matriculated graduate credits for the MS in CS (subject to approval by the program director).

The admission requirements for non-matriculated students are mostly the same as for degree program students: A bachelor's degree with a grade-point-average of at least 3.0 is required, and sufficient background in CS and in Mathematics, as described above. For applicants whose native language is not English, either the TOEFL or the GRE General Test are required. However, applicants for non-matriculated admission do not need letters of recommendation, nor the GRE General Test (except as a possible substitute for the TOEFL).

Fulfillment of the above requirements does not guarantee admission. Decisions about admissions are made by the Program Director and the Executive Committee of the CS Graduate Program.

Application forms can be obtained from the

Office of Graduate and Undergraduate Admissions
Rutgers, The State University of New Jersey
406 Penn Street
Camden, NJ 08102

or from `http://gradstudy.rutgers.edu`

Graduation requirements

• A minimum of **30 credits** must be completed, which must include either a project (project option) or a thesis (thesis option).

• There is a **breadth requirement**: At least *two* lecture courses must be taken from *each* of the following three areas (see also the section on course descriptions):

Theory: 56:198:571 Algorithms, 56:198:573 Computational Geometry, 56:198:575 Cryptography and Computer Security, 56:198:576 Theory of Computation, 56:198:577 Computational Complexity Theory, 56:198:578 Combinatorial Optimization.

Software/Systems: 56:198:521 Compiler Construction, 56:198:522 Program Transformation and Optimization, 56:198:523 Software Engineering, 56:198:531 Computer Systems Architecture, 56:198:543 Operating Systems, 56:198:546 Computer Networks, 56:198:548 Mobile and Wireless Computing.

Applications: 56:198:541 Parallel and Distributed Computing, 56:198:551 Database Systems, 56:198:552 Advanced Database Systems, 56:198:556 Computer Graphics, 56:198:582 Introduction to Computational Biology.

• **Grade requirements:** To graduate, the student must achieve a cumulative **GPA of 3.0**, or better, in the required 30 graduate credits. No more than 6 credits with grades of C or C+ may be used in meeting the requirements of the master's degree.

• **Project vs. thesis option:** The project option requires 9 lecture courses (27 credits) and a master's project (3 credits). (By "lecture" course is meant a regular, lecture-based course; independent study, research, or project credits are not lecture courses.)

A student taking the project option must enroll in the one-semester 3-credit course, 56:198:693 (Master's Project in Computer Science), supervised by a graduate faculty member. As part of this course, the student must complete either a design project (which includes a written report), or write a research report on a computer science topic based

on a collection of papers in the research literature. Additionally, the student must make an oral presentation of the completed project or research report at the culmination of the course.

The thesis option requires 8 lecture courses (24 credits) and a master's thesis (6 credits). Admission to the thesis option is highly selective and requires departmental approval.

To be eligible for the thesis option, a student must have completed at least 4 graduate courses and have a cumulative graduate GPA of at least 3.5. Furthermore, the student must have the endorsement of a graduate faculty member who will serve as the student's thesis adviser. If approved for the thesis option, the student will take 6 credits of 56:198:701,702, called "Research in Computer Science". The student must submit a written report and give an oral presentation of the thesis project in front of a committee of graduate faculty members.

• **Writing requirement and comprehensive exam:** In both the thesis option and the project option, the Graduate School's writing requirement is fulfilled by the written report, and the Graduate School's comprehensive exam requirement is fulfilled by the presentation; the examining committee will evaluate the candidate's general knowledge in computer science.

• **Transfer credits:** Subject to approval by the Program Director, students may transfer up to 10 credits from other graduate Computer Science programs toward their MS CS degree provided they satisfy the following conditions:
1. The student has completed at least 12 credits with grades of B or better at the Graduate School - Camden.
2. The courses transferred cannot include credits for a thesis, independent study, or research.
3. The transferred credits have not been (and are not intended to be) counted towards any other degree.
4. The courses transferred have been taken during the six years prior to the application for transfer of credits.

(See `http://catalogs.rutgers.edu/generated/cam-grad/pg875.html` .)

• **General rules of the Graduate School:**
`http://catalogs.rutgers.edu/generated/cam-grad/pg923.html` .

Curriculum outline of a typical course of study

The MS CS program is designed to be completed in between three semesters of full-time study, and five semesters of part-time of study. All courses reserved for MS students (i.e., at the 500-level) will be taught in the evening. Examples of course sequences for 3, 4, and 5 semesters of study are given below (with reference to the breadth requirement areas mentioned earlier).

Three Semesters: 12 + 12 + 6 credits

Semester 1	**Semester 2**	**Semester 3**
Theory I	Theory II	Elective
Systems I	Systems II	Project or Thesis II
Applications I	Elective or Thesis I	
Applications II	Elective	

Four Semesters: 9 + 6 + 9 + 6 credits

Semester 1	**Semester 2**	**Semester 3**	**Semester 4**
Theory I	Theory II	Applications II	Elective
Systems I	Systems II	Elective	Project or Thesis II
Applications I		Elective or Thesis I	

Five Semesters: 6 + 6 + 6 + 6 + 6 credits

Semester 1	Semester 2	Semester 3	Semester 4	Semester 5
Theory I	Applications I	Theory II	Elective	Elective
Systems I	Systems II	Applications II	Elective or Thesis I	Project or Thesis II

Accelerated joint BS-MS degree program

Students who demonstrate exceptional academic performance in the undergraduate Bachelor of Science program (BS) in Computer Science at Rutgers-Camden can apply to an accelerated program that will permit a completion of a joint BS-MS degree in a total of 5 years. To qualify for admission into this program, an undergraduate student in the BS program must meet the following requirements by the end of the Fall semester in the third (junior) year:

• completion of at least 80 credits towards the BS degree with a cumulative GPA of 3.25 or higher;

• completion of all the computer science requirements for the BS degree (except possibly the two core courses: 50:198:476 Intro. to the Theory of Computation and 50:198:493 Senior Design Project, and two CS electives) with a GPA on the completed computer science courses of 3.6 or higher.

Students who meet the above requirements may apply to be admitted to the 5-year joint degree program by providing the following documents in the Spring semester of their junior year:

• Complete transcripts until the end of the Fall semester of the junior year.

• Three letters of recommendation.

• A personal statement (of at most two pages) on academic interests, graduate school plans, and career goals.

• Ootionally, other supporting information, such as work or research experience and special skills.

The GRE General (Aptitude) Test requirement will be waived for the accelerated undergraduate admission.

Once admitted, it is the student's responsibility to finish the remaining BS degree requirements in the fourth year of undergraduate studies and ensure that the overall GPA on all CS undergraduate courses remains above 3.5 at the end of the 4th year. Among the CS courses taken in the senior year, up to two CS courses that are also cross-listed for graduate credit in the program may be double-counted (i.e., they count for both undergraduate and graduate credit). The student (in consultation with the Graduate Program Director) will devise a course plan that will ensure that he/she completes the individual requirements of both degree programs.

A student who has been admitted to the accelerated program but subsequently fails to meet the above requirements by the end of the senior year will not be able to double-count any courses for the graduate and undergraduate programs; also, in that case the student must submit GRE General (Aptitude) test scores showing satisfactory performance no later than the end of the 9th semester.

The following table shows a typical time-line and a plan of courses that could be taken by a student to ensure completion of the joint BS-MS degree program in 5 years. The student obtains admission during semester 6 of the program below. Note that at least 2 or 3 courses that count towards graduate credit will need to be completed by the end of the 4th year (i.e., the 8th semester).

Period	CS courses taken	Min. credits by end of period
Semesters 1–5	111, 112, 113, 114, 171 213, 231, 321	80
Semester 6	323, 371, 476, 1 BS elective	95
Semester 7	2 BS electives, Theory I	110
Semester 8	493, 1 BS elective, Systems I	126
Semester 9	Theory II, Applications I 1 MS Elective MS elective or Thesis I	138
Semester 10	Applications II 1 MS elective, Systems II Project or Thesis II	150

Course Descriptions

The following courses are in the gradaute catalog for the MS CS program[1]. Some are upper-level courses in the undergraduate curriculum that will be cross-listed, or graduate courses in the MCS Graduate Program in Mathematics.

56:198:521 Compiler Construction (3 credits)

Prerequisite: None.

Introduction to compiler design and implementation, including lexical analysis, formal syntax specification, parsing techniques, syntax-directed translation, semantic analysis, execution environment, storage management, code generation, and optimization techniques.

56:198:522 Program Transformation and Optimization (3 credits)

Prerequisite: 50:198:321 or equivalent.

Introduction to program development and optimization-by-transformation, using the lazy functional language Haskell. Use of program transformation to achieve scalability of processes and methods in software engineering. Applications in compilation, optimization, refactoring, program synthesis, software renovation, and reverse engineering.

56:198:523 Software Engineering (3 credits)

Prerequisite: None.

Theory and practice of process life cycle, project planning, requirements capture, software design, team programming, unit and integration testing, system delivery and maintenance, process and product evaluation and improvement. One or more recent process approaches - such as pair programming, extreme/agile programming, unified software process, and component-based software engineering models - such as CORBA, COM, EJB.

56:198:531 Computer Systems Architecture (3 credits)

[1]The numbering scheme for 500-level courses is as follows: 52x: languages/software courses; 53x and 54x: systems and hardware courses; 56x: mathematical computer science; 57x: theory courses; 55x and 58x: applications courses; 59x: special topics, thesis and project courses

Prerequisite: None.

Processor design; memory hierarchy; cache coherence and consistency; input/output subsystems; multiprocessor and massively parallel architectures.

56:198:541 Parallel and Distributed Computing (3 credits)

Prerequisite: None.

Fundamental issues in the design and development of algorithms and programs for parallel computers. Programming models and performance optimization techniques; application examples and programming exercises on a contemporary parallel machine; cost models and performance analysis and evaluation.

56:198:543 Operating Systems (3 credits)

Prerequisite: None.

A comprehensive, hands-on coverage of operating system principles, design and implementation. Topics include: kernel development; process concurrency issues such as starvation, mutual exclusion, deadlock avoidance, concurrency models and mechanisms, producer-consumer problems, and synchronization; scheduling policies and algorithms for preemptive and non-preemptive scheduling; real-time scheduling; memory management and analysis of paging and segmentation policies; security and protection; file systems; fault tolerance; performance evaluation.

56:198:546 Computer Networks (3 credits)

Prerequisite: None.

Introduction to computer communication networks, including physical and architectural components, communication protocols, switching, network routing, congestion control, and flow control. End-to-end transport services, network security and privacy. Networking software and applications. Network installation, testing and maintenance.

56:198:548 Mobile and Wireless Computing (3 credits)

Prerequisite: None.

Digital communication, radio transmission basics, the mobile environment, communication channels, access technologies (FDMA, CDMA, TDMA), channel assignment algorithms, user location and tracking, handoff, packet radio networks, ad-hoc networks, satellite networks, security and authentication issues, mobile IP, power control.

56:198:551 Database Systems (3 credits)

Prerequisite: None.

Relational database theory and practice, including database design. Database concepts, relational algebra, data integrity, query languages, and views. Introduction to object-oriented databases. Application project with a practical database management system.

56:198:552 Advanced Database Systems (3 credits)

Prerequisite: 50:198:551 or equivalent.

Query processing, including indexing and hashing; query optimization; transaction management, including concurrency control and recovery; database architecture, including server and network systems. Project based on designing and implementing enterprise systems.

56:198:556 Computer Graphics (3 credits)

Prerequisite: None.

Graphics systems and imaging principles, graphics programming using packages like OpenGL, input devices and interactive techniques, animation techniques, geometric transformations and modeling in two and three dimensions, viewing in 2D and 3D, lighting and shading, fundamental graphics algorithms (such as clipping, hidden surface removal etc.).

56:198:557 Advanced Computer Graphics (3 credits)

Prerequisite: 56:198:556 or equivalent.

Advanced topics in computer graphics, with a focus on rendering (hidden surface and visibility algorithms, material properties and reflection models, techniques for global illumination calculations, including ray tracing and radiosity algorithms) and modeling (methods for describing geometric primitives such as implicit surfaces and parametric patches, solid modeling and constructive solid geometry).

56:198:561, 562 Algebra for Computer Scientists, I, II (3,3 credits)

Prerequisite: None.

Cross-listed with 56:645:535-536. Linear and abstract algebra, including group theory, with applications to image processing, data compression, error correcting codes, and encryption.

56:198:563 Computational Number Theory and Cryptography (3 credits)

Prerequisite: None.

Cross-listed with 56:645:540. Primes and prime number theorems and numerical applications; the Chinese remainder theorem and its applications to computing and to hash functions; factoring numbers; cryptography; computational aspects of the topics covered. Students are required to do some simple programming.

56:198:565-566 Computational Mathematics I,II (3,3)

Prerequisite: None.

Cross-listed with 56:645:571-572.

Newton's method, curve and surface fitting. Numerical solutions of differential equations and linear systems, eigenvalues and eigenvectors. Fast Fourier transform.

56:198:571 Algorithms (3 credits)

Prerequisite: None.

Cross-listed with 56:645:537

Review of general tools and techniques in the design and analysis of algorithms and their proof of correctness. Selected topics from: graph algorithms, algebraic and geometric algorithms, randomized algorithms, online algorithms.

56:198:573 Computational Geometry (3 credits)

Prerequisite: None.

Cross-listed with 56:645:541

Algorithms and data structures for geometric problems that arise in various applications such as computer graphics, CAD/CAM, robotics, and geographical information systems (GIS). Topics include: point location, range searching, intersection, decomposition of polygons, convex hulls, Voronoi diagrams, and line arrangements.

56:198:575 Cryptography and Computer Security (3 credits)

Prerequisite: None.

Secret-key cryptography, public-key cryptography, key agreement, secret sharing, digital signatures, message and user authentication, one-way functions, key management; attacks; practical applications to computer and communications security.

56:198:576 Introduction to the Theory of Computation (3 credits)

Prerequisite: None.

Cross-listed with 56:645:533

Formal languages, automata and computability: regular languages and finite-state automata; context-free grammars and languages; pushdown automata; the Church-Turing thesis; Turing machines; decidability and undecidability.

56:198:577 Computational Complexity Theory (3 credits)

Prerequisite: 56:198:576 or equivalent.

Cross-listed with 56:645:534

Fundamental mathematical concepts, models of computation, uncomputability, notions of space and time complexity. Complexity classes and reductions.

56:198:578 Combinatorial Optimization (3 credits)

Prerequisite: None.

Cross-listed with 56:645:538

Introduction to linear optimization and the theory of linear programming. Topics include: the simplex method; duality; network flow problems; graph matching; integer programming; NP-completeness and introduction to both LP-based and combinatorial techniques for designing approximation algorithms.

56:198:582 Introduction to Computational Biology (3 credits)

Prerequisite: None.

Basic overview of biochemistry and bio-molecules: DNA, RNA, amino acids and proteins; sequence alignment problems, protein structure prediction; introductory phylogenetics; use of public databases.

56:198:691,692 Special Topics in Computer Science (3 credits each)

Prerequisite: As announced or permission of instructor.

In-depth study of areas not covered in regular courses. Topics vary from term to term.

56:198:693 Master's Project (3 credits)

Prerequisite: Permission of instructor.

Open only to students pursuing the project option. Design, implementation and demonstration of a significant software project. Project proposals must be approved by instructor. Project completion requires a written report and an oral presentation.

56:198:694 Independent Study in Computer Science

Prerequisite: Permission of instructor.

Designed for students who wish to conduct original research in computer science.

56:198:701,702 Research in Computer Science (3 credits each, in sequence)

Prerequisite: Permission of thesis adviser and the graduate director.

Open only to students pursuing the thesis option. This will involve two semesters' worth of substantial and independent research on a topic approved by a faculty member (the thesis adviser) who will work closely with the student. This research will be exposited in the student's MS thesis, and will require an oral presentation.

56:198:800 Matriculation Continued (0 credits)

Continuous registration may be accomplished by enrolling for at least 3 credits in standard course offerings, including research courses, or by enrolling in this course for 0 credits. Students actively engaged in study toward their degree who are using university facilities and faculty time are expected to enroll for the appropriate credits.