Computer Science Program
Department of Electrical Engineering and Computer Science
College of Engineering and Architecture
Howard University

Graduate Handbook

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Ph.D./M.S. GRADUATE STUDY IN COMPUTER SCIENCE

Computer Science Program
Department of Electrical Engineering and Computer Science
College of Engineering and Architecture
Howard University

Revised Fall 2020

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Please contact us at (202) 806-6585 Mondays through Fridays from 9 a.m. - 4 p.m. Eastern Standard Time or send an e-mail to atgriffin@howard.edu or hugsadmission@howard.edu with your questions or to request additional information.

For the most up-to-date admissions information please visit our Graduate School Admissions Web pages atwww.gs.howard.edu.

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OUR PROGRAM AND THE COMMUNITY

The University and Community

Howard University is a comprehensive, research-oriented, historically black private university providing an educational experience of exceptional quality to students of high academic potential. Further, the University is dedicated to attracting and sustaining a cadre of faculty who are, through their teaching and research, committed to the development of distinguished and compassionate graduates and to the quest for solutions to human and social problems in the United States and throughout the world. This mission of the University is central to everything we do and can be found in a 1989 resolution of the Board of Trustees. With its reputation for providing high-quality education at an affordable price, Howard University is consistently ranked one of the nation's very best universities. Of the approximately 10,000 students enrolled, around 4,000 students are graduate and professional students.

Washington, D.C. is the capital city of the United States of America. The city and the surrounding area offer many cultural advantages, including its well-known monuments and inspiring memorials, and an excellent array of theater and music. The metropolitan area has a population over one million.

Our Program

The **computer science** program at Howard University is one of the first to be created in a historically black college and university (HBCU). The program's primary mission is to expand and diversify the pool of qualified individuals in the computing profession and to advance knowledge in computer science by providing high quality instruction and conducting research that addresses technical challenges and societal problems.

The computer science program will be the one of choice for students seeking high-quality undergraduate and graduate degree programs in computer science. The program will be recognized across the nation and the global community for research and education that produces diverse and versatile professionals. Graduates from our program will be able to:

- analyze, design, implement, and evaluate a computerized solution to a real-life problem using appropriate tools;
- work effectively as a team member;
- enter a professional computer science position or enter an appropriate graduate program;
- communicate effectively through speaking, writing, and the use of presentation tools;
- adapt to technological changes and innovations in the discipline;
- consider the ethical and societal concerns related to computers in society and apply this knowledge in the conduct of their careers.

The program offers a traditional B.S. degree in computer science, a computer science minor option for non-engineering disciplines at Howard, a graduate certificate program in Cybersecurity, a traditional M.S. degree in computer science, an accelerated 1-year M.S. degree in computer

science and a Ph.D. in computer science. **The B.S. curriculum** is a traditional computer science degree. The M.S. curriculum is oriented toward the design and application of computer systems and toward that portion of software engineering that guides and supports practice. The graduate certificate program prepares professionals in computer science and related areas to assume positions in secure systems development and managing the critical information security infrastructures in today's organizations. The **M.S. program** prepares highly competent and broadly skilled practitioners. A majority of the master's graduates work in industry, in companies ranging from small start-up operations to government labs and large research and development corporations. The **Ph.D. program** will prepare teachers and researchers for positions with universities, government research laboratories, and industry. Academic employment ranges from four-year colleges, where teaching is the primary focus, to positions at major research universities.

Currently, our faculty includes 11 tenured and tenure-track faculty and 3 adjuncts. We also have technical and administrative support staff. Most of our graduate students are full time. Students contribute to nearly every aspect of the program's operation. In addition to taking a wide variety of courses, they have the opportunity to participate in groundbreaking research, to teach, and to attend research group meetings. The local chapter of the Association of Computing Machinery (ACM), and the Upsilon Pi Epsilon (UPE) honor society sponsors both professional and social events. Students are strongly encouraged to seek membership of these organizations, however, membership of UPE is by invitation only.

Our student population is very diverse in terms of both geographic origin and previous degrees. While computer science, information systems, and mathematics represent the largest number of undergraduate majors among our graduate students, others majored in physics and engineering.

THE FACULTY AND THEIR RESEARCH

Our Faculty
For more details: http://www.cs.ceacs.howard.edu/faculty

Legand Burge III, Professor; Ph.D., Oklahoma State University, 1998. Distributed computing, mobile computing, operating systems, middleware, data communications, applied high performance computing.

Moses Garuba, Professor and Associate Dean for Academic Affairs; Ph.D., University of London, 2000. Information security, database security, secure electronic transactions, distributed algorithms, formal methods, computer forensics.

Noha Hazzazi, Assistant Professor; Ph.D., George Mason University, 2017. Formally modeling processes and automating the verification of process safety.

Harry Keeling, Associate Professor and Director of Undergraduate Admissions; Ph.D., George Mason University, 1998. Intelligent tutoring systems, machine learning, artificial intelligence, intelligent agents and web-based technology, expert systems.

Peter Keiller, Associate Professor; D.Sc., George Washington University, 1996. Software engineering process, reliability engineering, software testing, software fault tolerance, statistical modeling and analysis, performance modeling.

Jiang Li, Associate Professor and Director of Graduate Studies; Ph.D., Rensselaer Polytechnic Institute, 2003. Computer networking, network security, network simulation, data communications.

Chunmei Liu, Professor; Ph.D., University of Georgia, 2006. Bioinformatics, computational biology, algorithms, graph theory.

Linwei Niu, Assistant Professor, embedded systems and security.

Danda B. Rawat, Professor and Graduate Program Director; Ph.D., Old Dominion University, 2010. Cyber security, machine learning, data analytics and wireless networking for emerging networked systems including cyber-physical systems.

Todd Shurn, Associate Professor; Ph.D., Southern Methodist University, 1994. Computational optimization, heterogeneous data communication networks, web services and interoperability, interdisciplinary multi-media applications.

Gloria Washington, Assistant Professor; Ph.D., George Washington University, 2011. Human-computer interaction, human-centered computing, affective computing, and biometrics.

Research Areas
Our faculty conduct research in a broad range of research areas. Following is a quick reference index to their interests.

Research Labs and Center info can be found at http://www.eecs.cea.howard.edu/research-centers-and-labs

Algorithms and Complexity Theory
Chunmei Liu

Artificial Intelligence
Danda B. Rawat, Harry Keeling, Reginald Hobbs

Bioinformatics and Computational Biology
Chunmei Liu, Legand Burge

Computer Architectures
Legand Burge, Jiang Li, Moses Garuba

Cyber Security and Privacy
Danda B. Rawat, Moses Garuba

Databases and Data Visualization and Analysis
Moses Garuba, Peter Keiller

Data Analytics, Edge, and Cloud Computing
Danda B. Rawat, Moses Garuba, Jiang Li

Data Communications and Networking
Jiang Li, Danda B Rawat, Legand Burge, Todd Shurn,

Distributed/Parallel Computation and Operating Systems
Legand Burge, Moses Garuba, Danda B Rawat, Jiang Li

Information Assurance and Computer Security
Danda B. Rawat, Jiang Li, Moses Garuba, Legand Burge

Machine Learning and Big/Small Data Analytics
Danda B. Rawat

Internet of Things and Cyber Physical Systems
Danda B. Rawat

Mobile Computing
Legand Burge, Gloria Washington, Jiang Li

Multimedia Systems, Gaming, and WWW Applications
Todd Shurn, Legand Burge, Gloria Washington

Human-Computer Interaction, Human-Centered Computing
Gloria Washington, Danda B. Rawat

Performance Modeling and Simulation
Peter Keiller, Legand Burge, Gloria Washington, Danda B. Rawat, Jiang Li

Blood Supply Chain Safety
Noha Hazzazi

Software Engineering and Environments
Peter Keiller, Gloria Washington

Wireless Networking and Security
Danda B. Rawat

Systems Engineering

Peter Keiller
Faculty Contact Information

Graduate Program Director, Computer Science Programs

Danda B. Rawat, Professor	Danda.Rawat@howard.edu http://www.eecs.cea.howard.edu/users/drawat	202-806-2209	2120B Downing Hall

Faculty:

EECS Faculty Profiles can be found at http://www.eecs.cea.howard.edu/faculty

Peter Keiller, Associate Professor	pk@scs.howard.edu http://www.eecs.cea.howard.edu /users/pkeiller	(202) 806-4828	2112 Downing Hall
Jiang Li, Associate Professor	lij@scs.howard.edu http://www.eecs.cea.howard.edu /users/jli	(202) 806-4861	2038B Downing Hall
Harry Keeling, Associate Professor	hkeeling@howard.edu http://www.eecs.cea.howard.edu /users/hkeeling	(202) 806-4830	1016 Downing Hall
Todd Shurn, Associate Professor	shurn@scs.howard.edu http://www.eecs.cea.howard.edu /users/tshurn	(202) 806-4824	1110 Downing Hall
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Moses Garuba, Professor	moses@scs.howard.edu http://www.eecs.cea.howard.edu /users/mgaruba	(202) 806-4371	B36B Mackey
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Chunmei Liu, Professor	chunmei@scs.howard.edu http://www.eecs.cea.howard.edu /users/cliu	(202) 865-0056	2038A Downing Hall
Noha Hazzazi, Assistant Professor	noha.hazzazi@howard.edu http://www.eecs.cea.howard.edu/users/nhazzazi	(202) 865-6585	2014 Downing Hall
Linwei Niu, Assistant Professor	linwei.niu@howard.edu http://www.eecs.cea.howard.edu/users/linweiniu	(202) 865-6585	Downing Hall

DEGREE PROGRAMS AND ADMISSIONS INFORMATION

Overview of M.S. Degree Programs and Requirements

The Master of Science in Computer Science (MSCS) program involves (i) 24 credit hours of course work beyond the baccalaureate (BS) degree and 6 credit hours of thesis work (for MS in Computer Science with the Thesis Option) or (ii) 33 credit hours of course work beyond the baccalaureate (BS) degree and successful completion of comprehensive examinations in at least two graduate courses taken in the student's area of concentration/specialization (for MS in Computer Science with the Non-Thesis Option).

The MSCS program equips students with comprehensive knowledge of contemporary computer science through training that combines both theory and practice. The program provides intensive preparation in the concepts and techniques related to the design, programming, and application of computing systems. The program requires students to take a broad spectrum of courses, while simultaneously allowing for emphasis in desired areas of specialization. The MSCS program offers the following computer science specializations. (The course work must include the courses listed below or their equivalent):

- **CSCI 570** Advanced Algorithms (3credits)
- **CSCI 551** Advanced Software Engineering I (3credits)
- **CSCI 510** Computer Architecture (3credits)
- **CSCI 572** Computability and Complexity (3credits)
- **CSCI 680** Advanced Operating Systems (3credits)
- **CSCI 500** Socially Relevant Computing (2 credits)
- **CSCI 600** Research Methods (1 credit)

The remaining courses must be selected from the elective options in areas of specialization (pages 10-11). Admission Requirements for M.S. and Ph.D. programs are the same.

Overview of Ph.D. Degree Programs and Requirements

The program offers a Doctor of Philosophy (Ph.D.) in a range of specializations. All Ph.D. students:

1. Must complete a minimum of 72 credit hours beyond the baccalaureate (BS) degree, of which a minimum of 60 credit hours must be spent in course work and 12 credit hours in dissertation work
2. Must complete a minimum of 48 credit hours beyond the master's degree, of which a minimum of 36 credit hours must be spent in course work and 12 credit hours in dissertation work.

All students must be enrolled during the semester their degree is awarded, must be enrolled at Howard University a minimum of 4 semesters. At most 6 credit hours of undergraduate course

work can be applied to the program but must be approved by the faculty advisor and graduate program director.

Ph.D. Program

The Ph.D. program in the Computer Science program provides intensive preparation in the concepts and techniques related to the design, programming, and application of computing systems. The program requires the student to declare a major and minor. The major must be selected from one of the specializations below. The minor can be a computer science specialization or from any specialization offered in any other graduate program at Howard University. The student's minor selection must be approved by their major advisor to assure synergy between the selected major and minor specializations. The Computer Science program at Howard University offers the following computer science specializations:

- Software engineering
- Cybersecurity
- Machine learning and artificial intelligence
- Computer networks
- Computing systems.
- Computational science

Ph.D. Admission Requirements

1. A bachelor's degree in computer science, information systems, mathematics, or engineering from an accredited college or university.
2. At least one year of programming courses. Applicants should possess a working knowledge of at least two high-level programming languages. At least one of these languages should be C, C++ or Java.
3. A course in data structures in which the student is taught the basic data structures of linked lists, stacks, queues, and trees. The student should have extensive experience in writing programs that implement algorithms for manipulating these data structures.
4. An additional course involving machine organization. This requirement can be fulfilled by a course in operating systems, assembly language programming, computer organization, computer architecture, or similar courses.
5. At least one course in computer science having the data structures course as a prerequisite. This requirement can be fulfilled by a course in algorithms, algorithm analysis, numerical analysis, or a similar course.
6. One semester of operating systems
7. One semester of an algorithms course
8. Either one semester of probability and statistics or an equivalent course
9. One year of calculus
10. One semester of upper-level courses in differential equations, linear algebra, abstract algebra, or discrete mathematics. The course should have calculus as a prerequisite.
11. A cumulative grade point average of 3.0 on a 4.0 scale is required, and a cumulative grade point average of 3.0 in major course work is required.
12. Applicants should also satisfy all additional admission requirements of the graduate school.

Ph.D. Degree Requirements

To advance to candidacy for the Ph.D. of Computer Science degree, a student must attend the Responsible Conduct of Research Workshop, pass the compressive exam in the first semester of the second semester of their program, pass the Expository Writing Exam, successfully pass the qualifying examination, complete the core course requirements listed below and remaining credit hours through elective courses.

Each student must take the following core courses:

- **CSCI 570** Advanced Algorithms (3 credits)
- **CSCI 551** Advanced Software Engineering I (3 credits)
- **CSCI 510** Computer Architecture (3 credits)
- **CSCI 572** Computability and Complexity (3 credits)
- **CSCI 680** Advanced Operating Systems (3 credits)
- **CSCI 500** Socially Relevant Computing (2 credits)
- **CSCI 600** Research Methods (1 credit)

The remaining credit hours are to be selected from the elective options for the various areas of specialization, in consultation with the student's advisor and in accordance with individual needs and interests.

AREAS OF SPECIALIZATION

Software Engineering:
- **CSCI 552** Advanced Software Engineering II
- **CSCI 540** Object-Oriented Development
- **CSCI 683** Special Topics in Software Engineering
- **CSCI 783** Advanced Topics in Software Engineering

Cybersecurity:
- **CSCI 653** Cybersecurity I
- **CSCI 654** Cybersecurity II
- **CSCI 659** Capstone in Security
- **CSCI 652** Special Topics in Cybersecurity
- **EECE 676/CSCI 676** Cybersecurity for Net CPS/IoT

Machine Learning/Artificial Intelligence:
- **CSCI 660** Artificial Intelligence
- **CSCI 672** Intro to Machine Learning
- **CSCI 673** Knowledge Engineering and Management
- **CSCI 685** Special Topics in Artificial Intelligence
- **CSCI 785** Advanced Topics in Artificial Intelligence

Computer Networks:
- **CSCI 548** Data Communications I
- **CSCI 549** Data Communications II
- **CSCI 550** Network Modeling and Analysis
- **ECE 487** Telecommunications
- **ECE 460** Wireless Communications
- **CSCI 686** Special Topics in Data Communications
- **CSCI 786** Advanced Topics in Computer Networks

Computing Systems:
- **CSCI 560** Performance Modeling
- **CSCI 682** Parallel Computing
- **ECE 416** Microprocessors and Microcomputers
- **ECE 420** Introduction to VLSI design
- **CSCI 632** Advanced Database Systems
- **CSCI 687** Special Topics in Computing Systems
- **CSCI 787** Advanced Topics in Computing Systems

Computational Systems:
- **CSCI 574** Computational Biology
- **CSCI 532** Advanced Operations Research
- **CSCI 634** Advanced Modeling and Simulation
- **CSCI 674** Advanced Systems Management and Analysis
- **CSCI 688** Special Topics in Computational Systems
- **CSCI 788** Advanced Topics in Computational Systems

a) **Responsible Conduct of Research Workshop Requirement.** Each student is required to take the Responsible Conduct of Research Workshop in the first semester of the graduate program. Attending and participating in this workshop is a requirement for all degrees offered by the Graduate School, including the Master of Computer Science. Details on this program, including registration, dates, and times can be found at the Graduate School's web site.

b) **Expository Writing Requirement.** Each student is required to take the Expository Writing Examination in the first semester of the graduate program. Passing an Expository Writing Examination is a requirement for all degrees offered by the Graduate School, including the Master of Computer Science. Details on this program, including seminars for preparation to take the exam, examination dates, registration for the examination, and courses/workshops can be found at the Graduate School's web site.

Important Notes:
- Students must pass a comprehensive Exam within the first year in the program to stay in the PhD program. The exam will consist of five two-hour tests, with each test covering one of the five core areas. For each core area that is tested, a student must score a minimum of 85% to obtain a high pass and a minimum of 70% to obtain a low pass. A high pass is

required in at least four of the core areas on the comprehensive exam. The exam will be offered once at the beginning of the Fall/Spring semesters. There is a limit of two times a student can take the exams. If a student is unable to pass the comprehensive exams after two tries for extraordinary reasons, he/she can appeal to the graduate program committee for the third try by submitting a written letter and necessary support documentation. The committee decides whether or not to approve the appeal. A student can appeal only once.

The student must select a graduate study advisor during the first year of the program that covers the selected major specialization. With the assistance of the graduate advisor the student can make recommendations for the remaining members of their graduate committee. At least one member must be outside of the university (external reviewer). At least one member must be in the minor area. Under normal circumstance there are 5 members of the committee. The majority of the committee must be from the Department of Electrical Engineering and Computer Science.

In case of separation for student from adviser and vice versa, it should be approved by student's adviser, graduate program director and department chair before funding the new advisor.

- The student's proposal must be approved by the advisor before it is presented and defended to the whole committee. The proposal defense is open to the whole department.

- The whole dissertation committee (excluding the external reviewer) must approve the proposal before the student is approved to move forward with the dissertation. The proposal defense includes the student's defending the 'social relevance' of the proposed effort. The detailed procedure of approaching Ph.D. candidacy is elaborated in the following section.

- The student must in minimum publish two conference articles and have one journal article accepted (with no or minor revision) in the dissertation area in order to earn the degree. The quality of articles should be justifiable with objective metrics such as the impact factor of journals, the acceptance ratio of conferences and the citation number of a single article. A general guideline is for a journal to have an impact factor (as defined by Journal Citation Report) of no less than 0.9 or an H-index (as used by Google Scholar) of no less than 10 or an SCImago Journal Rank indicator of no less than 355, for a conference to have an acceptance rate of no more than 30%, and for an article to be cited for no less than 5 times (excluding self-citation). If the adopted metrics or metric values are arguable, they must be approved by the Graduate Program Committee.

- The thesis completed by the student must constituent significant innovation in the discipline of computer science, albeit the innovation may be applied to other disciplines. The definition of computer science quoted from Wikipedia is provided below.

  "Computer science is the scientific and practical approach to computation and its applications. It is the systematic study of the feasibility, structure, expression, and mechanization of the methodical procedures (or algorithms) that underlie the

acquisition, representation, processing, storage, communication of, and access to information, whether such information is encoded as bits in a computer memory or transcribed in genes and protein structures in a biological cell."

To help with understanding, an approximate single-sentence summary of the definition is that computer science is the study of information handling using computers.

The areas of computer science, also quoted from Wikipedia, include

- Theoretical computer science
    - ✓ Theory of computation
    - ✓ Information and coding theory
    - ✓ Algorithms and data structures
    - ✓ Programming language theory
    - ✓ Formal methods
- Applied computer science
    - ✓ Artificial intelligence
    - ✓ Computer architecture and engineering
    - ✓ Computer Performance Analysis
    - ✓ Computer graphics and visualization
    - ✓ Computer security and cryptography
    - ✓ Computational science
    - ✓ Computer networks
    - ✓ Concurrent, parallel and distributed systems
    - ✓ Databases
    - ✓ Health informatics
    - ✓ Information science
    - ✓ Software engineering

Should arguments be raised, the Graduate Program Committee has the right of the final judgments.

- Upon completion of the dissertation the student must defend their effort in a session open to the university. The dissertation must be approved by the whole committee in order to fulfill the dissertation requirement toward the Ph.D.

Ph.D. Candidacy Procedure

The following flow chart describes the procedure:
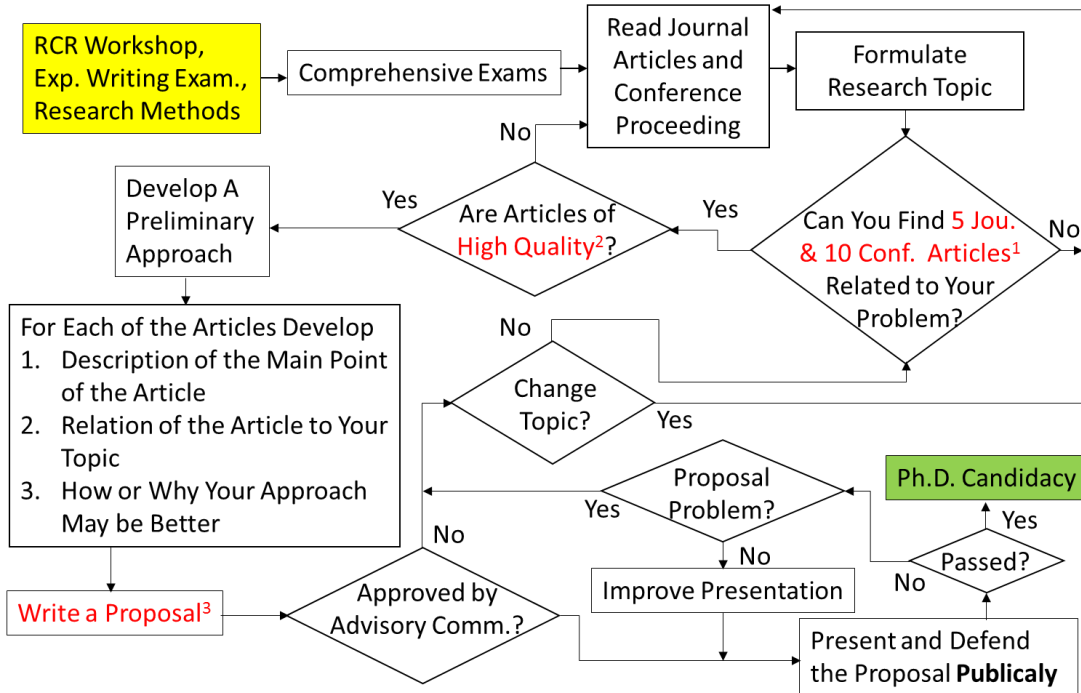
Remarks:

1. Five journal and ten conference articles are the minimum. There is no upper limit of the number of articles. There is also no source restriction beyond the five journal and ten conference articles.
2. Articles that meet the one of the following conditions are considered of high quality:
   – In journals of impact factors (as defined by Journal Citation Report) >= 0.9, or
   – In journals of an H-index (as used by Google Scholar) of no less than 10, or
   – In journals of an SCImago Journal Rank indicator of no less than 355, or
   – In conferences of acceptance rate <= 30%, or
   – With >= citations.
3. A written proposal includes the following content:
   – Preliminary literature review
   – Preliminary approach
   – Preliminary results (optional)

   A written proposal has the following format:
   – 10 pages minimum including bibliography
   – 11-pt fonts
   – Single line spacing

Plan of Study

In collaboration with their individual advisors, all Ph.D. students must complete the deliberation of their study plan (and update every semester) and submit it to the director of graduate studies by the beginning of the semester being in the program. The plan shows how a student should progress through the program toward the degree, such as when to take which courses, when to take the

comprehensive exams, when to apply for candidacy and so on. The plan of study should be signed by the advisor of the student before submission and be approved by the director of graduate studies.

Once submitted and approved, the student should follow the plan unless catastrophic situation occurs. Minor revisions are allowed and should be approved by both the advisor and the director of graduate studies. Major revisions may result in disruption of the study and are strongly discouraged.

Graduate Courses

CSCI-510	Computer Architecture	3 Credits
This course aims to build on a prior knowledge of computer organization by exploring more advanced concepts related to the design of computer systems and components. Topics include processor design, instruction set design, and addressing; control structures and microprogramming; memory management, caches, and memory hierarchies; and interrupts and I/O structures.		

CSCI-570	Advanced Algorithms	3 Credits
This is a theoretical and advanced course in algorithms; it will present useful techniques for solving challenging programming problems, using efficient algorithms and data structures. It will also provide advanced techniques in the analysis of algorithms and the fine-tuning of algorithms to particular systems to improve performance.		

CSCI-551	Advanced Software Engineering I	3 Credits
This course aims to develop the broad understanding of the discipline of software engineering (gained in the earlier Software Engineering course) by considering the wider systems engineering context in which software plays a role. It aims to examine the concepts and techniques associated with a number of advanced and industrially relevant topics, relating to both the product and processes of software engineering.		

CSCI-520	Computability and Complexity	3 Credits
This course explores the relationship between problems, algorithms, and languages. Computability: finite automata, rewriting systems, Turing machines (linear speedup, robustness, and the Universal Turing machine). It presents recursive and recursively enumerable languages, the Church-Turing thesis, and complexity classes defined in terms of time, space, and circuits.		

CSCI-680	Advanced Operating Systems	3 Credits
This course presents an exciting range of materials from the broad field of operating systems, including basic operating system structure, file systems and storage servers, memory management techniques, process scheduling and resource management, threads, distributed systems, security and a few other advanced topics. It will also examine influential historical systems, important current efforts, extracting lessons both on how to build systems as well as how to evaluate them.		

CSCI-632	Advanced Database Systems	3 Credits
This course presents advanced database system design and implementation. It will start with the basic relational databases and then cover advanced topics in modern database systems, including object-oriented databases, XML databases, distributed databases, and on-line analytical processing. It will also present various data description and query languages, database design, and query processing and optimization, and also look at distributed object model, and data mining and data warehouses.		

CSCI-634	Computer Simulation and Modeling	3 Credits

This course will provide students with the ability to model, simulate and analyze complex systems in a reasonable time. This course is divided into three parts and covers advanced techniques in simulation model design, model execution and model analysis. A selection of model design techniques such as conceptual models, declarative models, functional models, constraint models, and multi-models will be introduced.

CSCI-548	Data Communications I	3 Credits

Includes data communications media, the ISO network model, network systems elements, local and large scale networks, and line protocols. Students will monitor performance of local area networks using appropriate hardware and will simulate some of the problems of network noise, excess traffic, performance of bridges and gateways, etc. in software. Requires the completion of a group or individual project involving the design, development and demonstration of a communication system and its protocols.

CSCI-549	Data Communications II	3 Credits

This course is a continuation of Data Communications I. It introduces further networking topics by discussing wireless networking, and the components of network management – fault management, performance, configuration, security and accounting.

CSCI-549	Computational Biology	3 Credits

Introduces computational methods for understanding biological systems at the molecular level. Problem areas such as mapping and sequencing, sequence analysis, structure prediction, phylogenic inference, regulatory analysis. Techniques such as dynamic programming, Markov models, expectation-maximization, local search.

CSCI-675	Intro. To Machine Learning	3 Credits

Techniques for learning from data and applying these algorithms to application settings. Topics covered include Bayesian methods, linear classifiers such as the perceptron, regression, and non-parametric methods such as k-nearest neighbors.

CSCI-653	Cybersecurity I	3 Credits

This course will provide an intensive overview of the field of cryptography, providing a historical perspective on early systems, building to the number theoretic foundations of modern day cryptosystems. Students will study how cryptosystems are designed, to match cryptosystems to the needs of an application, and basic cryptanalysis. Real life breaches of common cryptosystems will be presented to better convey the dangers that lurk in cryptosystem design and in the design of systems that rely on cryptography.

CSCI-654	Cybersecurity II	3 Credits

This course is a continuation of Computer Security I. It will present security policies, models, and mechanisms for secrecy, integrity, and availability. Topics include operating system models and mechanisms for mandatory and discretionary controls; data models, concepts, and mechanisms for database security; basic cryptography and its applications; security in computer networks and distributed systems; and control and prevention of viruses and other rogue programs.

CSCI-552	Advanced Software Engineering II	3 Credits
This course is a continuation of the course CSCI-551 (Software Engineering I). The emphasis of the course is on software engineering. Topics covered include verification, metrics, software fault tolerance, maintainability and reliability. Extensive use of the formal properties of algorithms is made. Prerequisite: CSCI-551 (Software Engineering I).			

CSCI-650	Artificial Intelligence	3 Credits
This course presents an overview of artificial intelligence and a survey of the major areas of the field. Course objectives are to study the various knowledge representation methods and techniques in solving AI problems in the literature, gain a level of proficiency in LISP that will enable the student to program an AI problem; design a solution to an AI problem using LISP or a specialized AI language.			

CSCI/EECE 676	Cybersecurity for Net CPS/IoT	3 Credits
This course is designed to introduce emerging topics related to cybersecurity challenges and practical cyber-defense/countermeasures in networked Cyber-Physical Systems (CPS) and Internet-of-Things (IoT). The course will cover fundamental concepts, technologies, theoretical understanding and practical basis for cybersecurity of networked CPS/IoT. Graduate students will complete an independent research project which involves a written and oral presentation not required at the undergraduate level.			

CSCI 532	Advanced Operations Research	3 Credits
This course will acquaint students with the formulation, solution, and implementation of operations research models for analyzing complex systems in industry or government, also familiarizing students with special techniques of the field such as linear programming and network analysis. Topics include Simplex Method, Duality Theory, and Network Analysis.			

CSCI-540	Object-Oriented Development	3 Credits
This course will provide a fundamental understanding of the object-oriented paradigm, and how it is used in analysis, requirement specification, design, and programming. Emphasis is on object-oriented design. Covers different specification techniques with a focus on the unified modeling language. Object-oriented databases, object-oriented user interfaces and object-oriented business processes, as well as standards in object orientation will be introduced.			

CSCI-550	Network Modeling and Analysis	3 Credits
This course presents various topics related to the design, modeling, and analysis of telecommunication networks, including queuing models, loss systems, overflow systems, simulations, and routing strategies. Emphasis will be placed on exact and approximate methods for measuring the performance of such networks. Upon completion of this course, students will be able to apply modeling techniques to telecommunication networks, based on specific characteristics, and measure the performance of each using both exact and approximate methods.			

CSCI-682	Parallel Computing	3 Credits
This course aims at exploring several alternative programming models and contrasting their suitability for different architectures and applications. The material covered will encompass topics in parallel computer architectures, parallel programming models, and languages. Appropriate examples for existing or proposed parallel architectures will be surveyed. Alongside, students will have the opportunity to gain hands-on experience with MPI and PVM.			

CSCI-685	**Special Topics in Software Engineering**	
This course will present special research projects in software engineering for students who wish to independently pursue reading and study in a topic mutually agreed upon by a member of the faculty and the student. Prerequisite: permission of the director of the Computer Science program.		
CSCI-686	**Special Topics in Cybersecurity**	
This course will present special research projects in information security for students who wish to independently pursue reading and study in a topic mutually agreed upon by a member of the faculty and the student. Prerequisite: permission of the director of the Computer Science program.		
CSCI 685	**Special Topics in Artificial Intelligence**	
This course will present special research projects in Artificial Intelligence for students who wish to independently pursue reading and study in a topic mutually agreed upon by a member of the faculty and the student. Prerequisite: permission of the director of the Computer Science program.		
CSCI 686	**Special Topics in Data Communications**	
This course will present special research projects in Data Communications for students who wish to independently pursue reading and study in a topic mutually agreed upon by a member of the faculty and the student. Prerequisite: permission of the director of the Computer Science program.		
CSCI 687	**Special Topics in Computer Systems**	**3 Credits**
This course will present special research projects for students who wish to independently pursue reading and study in a topic mutually agreed upon by a member of the faculty and the student. Prerequisite: permission of the director of the Computer Science program.		
CSCI-659	**Capstone in Security**	**3 Credits**
This course is the terminal project for the Information Security Certificate program. It requires the design, implementation, setup and configuration of realistic enterprise computing applications and environments. Securing the infrastructure and integration of different services and technology in efficient, secured and redundant manners, and utilizing open-source and commercial security products.		
CSCI 673	**Knowledge Engineering and Management**	**3 Credits**
Knowledge Engineering is the process of building and maintaining Knowledge structures, particularly intelligent problem-solving systems. Knowledge management is concerned with collecting and making accessible the knowledge structures most relevant to a particular set of stakeholders. This course covers selected methods from different areas of Knowledge Engineering and knowledge management. Topics include knowledge representation and reasoning, knowledge acquisition, knowledge synthesis and knowledge evolution.		
CSCI-599	**Master's Project**	**3 Credits**

This is the terminal work for the non-thesis option of the master's degree program. It affords the opportunity to conduct applied research, design, implement, setup and configure a realistic enterprise computing application and its environment. Candidates who select the Master's Project must choose a major professor to direct their project. The advisor and the student may identify other resource persons to serve in an advisory capacity for the project. Before beginning the project, student must present a project concept proposal to the major professor. The Director of Graduate Studies must approve this project. Student will write a project report and present the study at an announced open forum similar to the thesis defense. This report will not be on file in the Howard University library.

CSCI-699	Master's Thesis	3 Credits

The thesis option provides the student the opportunity to conduct original research and to report this in a scholarly manuscript. This option is especially well suited to a student who plans on pursuing a PhD degree. Students who select this option must choose a major professor to act as the chair of their thesis committee and two additional committee members. Before beginning work on a thesis, a student must present a proposal to their committee for approval. The committee will direct and supervise the work carried out by the student. The student is bound by the Graduate School rules and regulations for thesis defense.

Financial Support in the Program

Financial support in the computer science program is available in three forms:

1. **University Graduate Assistantships.** These positions carry a remission of tuition and the requirement that the student work 20 hours a week as a Teaching Assistant under the direction of the program, usually in support of program classes in beginning programming courses. These are often awarded very early in the application cycle. As a matter of policy, all entering graduate students are considered for such funding unless they state otherwise. A letter of interest addressed to the program director, resume, and transcript are all that is required for consideration. Selection criteria include: undergraduate major, GPA, relevant work experience and communications skills.
2. **Research Assistantships.** These are funded by faculty research grants, which are almost always based on funds the faculty member has obtained to support his or her area of research. These are often awarded at different times in the application cycle, since grants are awarded at different times. The funds also expire at different times during the academic year, depending on the particular grant or contract. As a matter of policy, all entering graduate students are considered for such funding unless they state otherwise. A letter of interest addressed to the program director, resume, and transcript are all that is required for consideration. Selection criteria include: undergraduate major, GPA, relevant work experience and communications skills.
3. **Graduate School funded support.** These funds are almost always handled entirely by the Graduate School. For more information on these funds, visit the graduate school website at www.gs.howard.edu.

Honor Code Policy for Projects or Research

Unless otherwise stated, at the time that an assignment or project is given, all work handed in for credit is to be the result of individual effort. (In some classes group work is encouraged; if so, that will be made explicit when the assignment is given.)

I. You (or your group, if a group assignment) may:
- seek assistance in learning to use the computing facilities;
- seek assistance in learning to use special features of a programming language's implementation;
- seek assistance in determining the syntactic correctness of a particular programming language statement or construct;
- seek an explanation of a particular syntactic error;
- seek explanations of compilation or run-time error messages

II. You (or your group, if a group assignment) may not seek assistance from anyone else, other than your instructor or teaching assistant:
- in designing the data structures used in your solution to a problem;
- in designing the algorithm to solve a problem;
- in modifying the design of an algorithm determined to be faulty;
- in implementing your algorithm in a programming language;
- in correcting a faulty implementation of your algorithm

- in determining the semantic correctness of your algorithm.

III. Unless permission to do so is granted by the instructor, you (or your group, if a group assignment) may not:

- give a copy of your work in any form to another student;
- receive a copy of someone else's work in any form;
- attempt to gain access to any files other than your own or those authorized by the instructor or computer center;
- inspect or retain in your possession another student's work, whether it was given to you by another student, it was found after other student has discarded his/her work, or it accidentally came into your possession;
- in any way collaborate with someone else in the design or implementation or logical revision of an algorithm;
- present as your own, any algorithmic procedure which is not of your own or of the instructor's design, or which is not part of the course's required reading (if you modify any procedure which is presented in the course's texts but which is not specifically mentioned in class or covered in reading assignments, then a citation with page number must be given);
- incorporate code written by others (such as can be found on the Internet);

IV. You must:

- report any violations of II and III that you become aware of;
- if part of a group assignment, be an equal "partner" in your group's activities and productions, and represent accurately the level of your participation in your group's activities and productions.

ADMISSIONS INFORMATION

The University promotes academic excellence through a highly selective admission process. Students who are admitted show strong personal motivation along with backgrounds of consistent academic growth and achievement. The University also attracts and seeks out socially and economically deprived students who show promise of gaining from a Howard University education.

To protect its character and standards of scholarship, the University reserves the right, and the applicant concedes to the University the right, to deny admission to any student at any time for any reason the University deems sufficient.

Note to Prospective Students

On September 24, 1983, the Board of Trustees of Howard University adopted the following policy statement regarding applicants for admission: "Applicants seeking admission to Howard University are required to submit accurate and complete credentials and accurate and complete information requested by the University. Applicants who fail to do so shall be denied admission. Enrolled students, who as applicants failed to submit accurate and complete credentials or accurate and complete information on their application for admission shall be subject to dismissal when the same is made known regardless of classification."

Any applicant with an acceptable academic record and an undergraduate degree from a regionally accredited institution or any international student with equivalent qualifications is eligible to apply for admission to the Graduate School. Applicants are expected to have received

adequate training in the fields in which graduate work is planned. The department in which the student plans to study shall determine whether or not the student's training is adequate. If a student is qualified to be admitted for graduate study in a particular graduate department, a recommendation for admission is made to the Graduate School by the program. Special admission criteria for the individual departments are included in the descriptions of the programs offered through the Graduate School.

A cumulative grade point average of 3.0 on a 4.0 scale is required, and a cumulative grade point average of 3.0 in major course work is required.

General Admission Requirements
- Completed on-line application and signature page or
- Download the paper application (PDF)
- The non-refundable $45 application fee (Waivers accepted for FAMU Feeder Program and McNair Scholars)
- Official transcripts must be submitted directly from the Registrar's Office from ALL colleges and universities attended (exceptions require the approval of the Dean)
- GRE Scores (Only official score reports are accepted within 5 years of the test date) www.gre.org GRE scores sent directly from ETS (HU code: 5297).
- Statement of Academic and Research Interest
- Autobiographical Sketch (Personal biography)
- Resume
- Three letters of recommendation sent directly to the Office of Graduate Recruitment and Admissions in a sealed envelope Word (MUST BE IN SEALED ENVELOPES)

International Applicants Admission Requirements
In addition to the requirements listed above you must submit the following:
- Official transcripts, final certificates and/or mark/grade sheets must be sent directly from the college or university to the Office of Graduate Recruitment and Admissions, and must show proof of degree(s) earned, courses taken and marks/grades received. In situations where the university will not send transcripts directly official transcripts, received indirectly, can be approved by the Dean's Office. Also, ALL transcripts must be evaluated by World Education Services (www.wes.org) or AACRAO (www.aacrao.org) and be forwarded to Graduate Recruitment and Admissions.
- If the transcripts are not in English, they must be accompanied by an official translated copy.
- All documents must bear the same name that appears on the admissions application unless an official document so submitted indicating a change of name.
- TOEFL Scores (Minimum computer-based score of 213 is required and only official score reports are accepted within 2 years of the test date) www.toelf.org. TOEFL scores must be sent directly from ETS (HU code: 5297).
- The TOEFL test is not required if you received a degree in the U.S.
- Statement of Financial Resources – A completed form that verifies proof of financial support (sufficient funds to cover expenses for one full year – as indicated on the graduate school website) and supporting financial documentation indicating sources of funds while

> attending Howard University (such as a certified bank statement dated within three months of registration).
- Verification of six months history with bank.

For information on how to apply and where to send materials for other graduate and professional programs at Howard University, visit the Graduate School webpage - www.gs.howard.edu

Caution to Prospective Students

The Board of Trustees of Howard University on September 24, 1983, adopted the following policy statement regarding applications for admission: "Applicants seeking admission to Howard University are required to submit accurate and complete credentials and accurate and complete information requested by the University. Applicants who fail to do so shall be denied admission. Enrolled students who as applicants failed to submit accurate and complete credentials or accurate and complete information on their application for admission shall be subject to dismissal when the same is made known, regardless of classification."

Application Deadlines

Please refer to https://gs.howard.edu/graduate-programs/computer-science
- **Fall Semester:** March 15**
- **Spring Semester:** October 15
- **Summer Semester:** March 15th

All credentials must be sent to:
Howard University Graduate School
Office of Graduate Recruitment and Admissions
4th and College Streets, N.W., Washington, D.C. 20059

Financial Support Programs

Merit-based financial support for Graduate Students is available through graduate research and teaching assistantships, fellowships, and tuition scholarships. Each category of support is awarded annually on a competitive basis. Award recipients are expected to perform specific duties for 15 hours per week during the academic year. The responsibilities, often described as an internship, are defined and evaluated by the academic department or the Graduate School depending upon the appointment. The selection / appointment process, eligibility criteria and award package for graduate assistantships, fellowships and tuition scholarships are described below:

Selection and Appointment

The selection process for each category of financial support is aggressively pursued between February and June for the subsequent academic year. New and continuing graduate students are encouraged to apply early for these awards with the academic chair or director of graduate studies. Additionally, students may apply for financial support administered through the Graduate School. The appointment for graduate assistants and fellows begins on August 15th and ends on May 15th of each academic year. Please note if a funding offer is not presented in writing by June 15 from the academic department or the Graduate School, the likelihood of obtaining one of these awards

is greatly diminished. After June 15th, new and continuing students are encouraged to seek external or need-based financial support for the upcoming academic year.

Eligibility

The minimum GPA requirement is 3.0 for new and 3.2 for continuing students. However, because these awards are merit-based and reviewed competitively, the definition of quality academic performance may vary. Award recipients must enroll for the fall and spring as full-time students defined by a minimum of 9 credit hours. Additionally, students are required to pay their own student fees each semester. (Click here for Eligibility details)

Award Package

The award package for graduate research / teaching assistantships and fellowships includes a 10-month tuition waiver and a minimum stipend (12,000 for master's students and 13,000 for Ph.D. students). In many cases, additional stipend support is available through funded grants. Students may inquire about these opportunities at the time of application submission.

Stipend Disbursement

Graduate research / teaching assistants and fellows should prepare to receive their stipend disbursement the first payroll date in September. The last disbursement occurs the final pay cycle in May. Please note new international graduate students typically receive the first stipend disbursement during the last pay cycle in September due to the process of obtaining a social security number. However, the first stipend amount will be greater to reflect the appointment date.

The Financial Aid Office is located in the Johnson Administration Building (Main Campus) Room 205, 2400 Sixth Street, N.W., Washington, DC 20059. Hours of operation are 8:30 a.m. - 3:00 p.m. Monday, Tuesday, Thursday and Friday. The office is open from 8:30 – 5:00 on Wednesdays.

http://www.howard.edu/financialaid/

Applications for financial support administered by the Graduate School should be mailed to:
Office of Retention, Mentoring and Support Programs
Howard University Graduate School
4th and College Streets, NW, Washington, DC 20059
ATTN: Fellowship Committee

GETTING REGISTERED

It is extremely important that you see your academic advisor prior to registering to ensure that you select the appropriate courses, complete a Request for Registration form, and get a personal identification number (PIN). Our current registration system is designed to prohibit students from registering for classes for which they have not completed the required pre- or co-requisite courses. Therefore, if you encounter a "registration error," this means that the system does not recognize you as having met the prerequisite(s) for the selected course. You must make another selection, or meet with your advisor for a course prerequisite override. If your advisor feels that you have met the prerequisite(s) for a particular course, he/she will approve your course selection.

1. Read over these instructions, or print them out. Once you are finished, go to the bottom of this page and click "Proceed to Bison Web Registration and Students Service".
2. Click LOG IN TO SECURE AREA on the Bison Web homepage.
3. Enter the "@" sign followed by your student identification number. Then enter your PIN. Your PIN must be six (6) numerical digits. Click the "LOGIN" button.

   For information on your PIN number, please use one of the following resources:
   - o Student Reference Manual (page 11)
   - o Your advisor
   - o Enrollment Management (202-806-2705)
   - o Courtesy desk in the Blackburn Center Ballroom
4. Type in your PIN again on the Login Verification Page, and click the LOGIN button.
5. If this is the first time you have signed on, a TERMS OF USAGE PAGE will display. Please read and if you accept the terms, click the CONTINUE button. If you do not accept the terms, click the EXIT button.
6. Select the phrase Student Services and Financial Aid.

7. Select the phrase Registration.
8. When the REGISTRATION page displays, click on SELECT TERM.
9. When the SELECT TERM page displays, click on the arrow at the right of the word TERM and select the appropriate term.
10. Click on the SUBMIT TERM button. The system will return you to the REGISTRATION page.
11. Click on CHECK YOUR REGISTRATION STATUS to assure you are able to register. If there are no holds which prevent registration click on the MENU at the top right of the page. If you are not able to register click the exit button at the top of the page.
12. When the registration page displays click on LOOK UP CLASSES TO ADD and follow the instructions.
13. When the classes are displayed, select the courses you want by clicking the boxes on the left side of the courses. When all courses are selected, click the REGISTER button. If there are no errors, you are now registered. If there are errors, you must restart from step 11.

This completes the registration process. Please verify your course selections by printing your schedule and making sure that the appropriate grade mode has been selected. If you need further assistance, call 202-806-2705.

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CONTACT US:
General Program Information
Phone: (202) 806-6585
FAX: (202) 806-4531
Web: http://www.eecs.cea.howard.edu

Surface Mail:
Computer Science Program
Department of Electrical Engineering and Computer Science
College of Engineering and Architecture
Howard University
L.K. Downing Hall
2300 Sixth Street, NW
Suite 1016
Washington, D.C. 20059

Graduate Admissions and Graduate Studies
Phone: (202) 806-6800
FAX: (202) 462-4053
Web: http://www.gs.howard.edu