

ENGINEERING, DOCTOR OF PHILOSOPHY (PH.D.) WITH A CONCENTRATION IN COMPUTER SCIENCE

Program mission

The mission of the Ph.D. in Engineering degree program is to provide graduate students with learning opportunities for acquiring a broad foundation of engineering knowledge, an in-depth original research experience at the frontiers of engineering, and skills for lifelong learning and professional development. Graduates of this program will pursue careers in research and development or academia.

1. **Advanced research skills:** To produce graduates who possess the necessary advanced analytical, technical and research skills in engineering and the sciences – responds directly to the higher goal of fulfilling the needs of industry, academe and research laboratories for effective, productive engineers, professors and researchers
2. **Communication:** To produce graduates who possess a facility with both written and oral communications – emanates from the requirement that engineers, researchers and professors must be able to interact and share ideas with others in the work environment, and at a higher level, be capable of creative self-expression, conveying knowledge and leadership
3. **Advanced problem-solving:** To produce graduates who demonstrate creativity and innovation in solving technological problems – stems from the realization that new knowledge and new solutions to existing problems are necessary to meet the needs of our changing society and to advance the quality of human life

Student learning outcomes

1. **Apply advanced knowledge of mathematics, science or engineering:** Graduates will demonstrate an ability to apply advanced knowledge of mathematics, science or engineering.
2. **Communicate effectively:** Graduates will demonstrate an ability to communicate effectively.
3. **Identify, formulate and solve engineering problems:** Graduates will demonstrate an ability to identify, formulate and solve engineering problems.
4. **Demonstrate abilities in research:** Graduates will demonstrate the ability to identify pertinent research problems, to formulate and execute a research plan, to generate and analyze research results, and to communicate those results through oral presentations and written publications. Graduates will be able to creatively solve the research problems posed.

VCU Graduate Bulletin, VCU Graduate School and general academic policies and regulations for all graduate students in all graduate programs

The VCU Graduate Bulletin website documents the official admission and academic rules and regulations that govern graduate education for all graduate programs at the university. These policies are established by the

graduate faculty of the university through their elected representatives to the University Graduate Council.

It is the responsibility of all graduate students, both on- and off-campus, to be familiar with the VCU Graduate Bulletin as well as the Graduate School website (<http://www.graduate.vcu.edu/>) and academic regulations in individual school and department publications and on program websites. However, in all cases, the official policies and procedures of the University Graduate Council, as published on the VCU Graduate Bulletin and Graduate School websites, take precedence over individual program policies and guidelines.

Visit the academic regulations section for additional information on academic regulations for graduate students. (<http://bulletin.vcu.edu/academic-regs/>)

Degree candidacy requirements

A graduate student admitted to a program or concentration requiring a final research project, work of art, thesis or dissertation, must qualify for continuing master's or doctoral status according to the degree candidacy requirements of the student's graduate program. Admission to degree candidacy, if applicable, is a formal statement by the graduate student's faculty regarding the student's academic achievements and the student's readiness to proceed to the final research phase of the degree program.

Graduate students and program directors should refer to the following degree candidacy policy as published in the VCU Graduate Bulletin for complete information and instructions.

Visit the academic regulations section for additional information on degree candidacy requirements. (<http://bulletin.vcu.edu/academic-regs/grad/candidacy/>)

Graduation requirements

As graduate students approach the end of their academic programs and the final semester of matriculation, they must make formal application to graduate. No degrees will be conferred until the application to graduate has been finalized.

Graduate students and program directors should refer to the following graduation requirements as published in the Graduate Bulletin for a complete list of instructions and a graduation checklist.

Visit the academic regulations section for additional information on graduation requirements. (<http://bulletin.vcu.edu/academic-regs/grad/graduation-info/>)

Other information

Student handbook (<http://www.egr.vcu.edu/current-students/graduate-student-services/resources-forms/>) is available on the College of Engineering website.

Apply online today. (<https://www.vcu.edu/admissions/apply/graduate/>)

Admission requirements

Degree:	Semester(s) of entry:	Deadline dates:	Test requirements:
Ph.D.	Fall	Jun 1 (Jan 15 for financial assistance)	GRE-General

Spring

Nov 15

TOEFL required
for international
students

graduate level and 18 credit hours of directed research for a minimum of 30 credits.

- A minimum of four courses that should satisfy the following:
 - At least two courses at the 600 level or greater
 - At least one course from each of the following two foundational areas: theory and systems.
- In each semester while in the doctoral program, students must take the one-credit hour CMSC 702 course.

Other students, including those with only a B.S. degree, must take a minimum of 60 credit hours of course work.

- A minimum of 33 didactic credits, including
 - At least two courses from each of the three foundational areas: theory, systems and applied computer science; CMSC 501 **must** be one of the courses taken.
 - At least 17 credits at the 600 level or greater.
- In each semester while in the doctoral program, students must take the one-credit hour CMSC 702 course.
- A minimum of 18 credits of directed research is required.

The Ph.D. program is independent from the M.S. in Computer Science program. Credits earned while in the Ph.D. program cannot be used to satisfy the requirements of the M.S. in Computer Science degree. Students admitted to the Ph.D. program cannot switch to the M.S. in Computer Science program and cannot obtain an M.S. in Computer Science degree in addition to the Ph.D. degree. In exceptional circumstances, the computer science graduate committee may allow a student to graduate with an M.S. degree instead of the Ph.D. degree based on a petition submitted to the committee by the student's adviser; students cannot petition for it.

Comprehensive examinations

Before advancing to doctoral candidacy, the student must pass both qualifying and oral comprehensive examinations.

Qualifying comprehensive examination

The qualifying examination focuses on the subject matter deemed critical as a foundation in the program.

- **The examination is largely based on material covered in required course work and its application to theoretical and practical problems.**
- The examination will cover knowledge in three areas, and in order to pass students must score a minimum of 75 percent in each area.
 - The exam must include material based on CMSC 501 from the theory area and on at least one course from the systems foundational area.
 - The third is the area of specialization based on courses to be decided by the dissertation adviser.
- Students are allowed to take the comprehensives based on courses they may not have taken at VCU, however, they have to satisfy the course requirements as mentioned above.
- Students can contact the lead professor for any area and obtain a list of topics that will be covered in the exam.
- The exam will be conducted a minimum of once a year and will be organized by the graduate director, with prior approval of the exam questions by the graduate committee.
- A student who fails the qualifying comprehensive exam is allowed one more attempt to pass it. The re-examination requires the approval of the student's advisory committee. A student who fails one area

Special requirements

- Acceptance of an applicant is based upon the recommendation of the admissions committee with approval of the program chair and the associate dean for graduate studies.
- Students may begin a course of study in either the fall or spring semesters for the engineering graduate programs, although a start in the fall semester is preferred.

In addition to the general admission requirements of the VCU Graduate School (<http://bulletin.vcu.edu/graduate/study/admission-graduate-study/admission-requirements/>), and the College of Engineering, applicants must meet the following requirements:

Applicants to the Ph.D. in Engineering with a concentration in computer science must have an M.S. degree in computer science or a field closely related to computer science, such as mathematics, physics, engineering or bioinformatics. Outstanding students (preferably with a B.S. degree in computer science) can be admitted into the direct B.S. to Ph.D. program.

Degree requirements

In addition to the VCU Graduate School graduation requirements (<http://bulletin.vcu.edu/academic-regs/grad/graduation-info/>), students must meet the following requirements.

A minimum of 60 credit hours beyond the bachelor's degree (typically a minimum of four years), or 30 credits beyond a master's degree (typically a minimum of three years), including research credits, is required for the Ph.D. in Engineering. Students may not present courses receiving grades less than C for fulfilling degree requirements and can only present up to six credit hours of course work receiving a grade of C.

A time limit of eight calendar years, beginning at the time of first registration, is placed on work to be credited toward the Ph.D.

Up to 30 percent of a student's required non-research graduate-level credits can be transferred into the Ph.D. program from another college or university. No more than 30 percent of student's non-research credits in graduate-level courses taken at VCU before admission to the Ph.D. program may be counted toward the Ph.D. degree.

A student will pursue a Ph.D. under the guidance of a computer science graduate faculty member who will serve as the dissertation adviser. Interdisciplinary programs of study that involve computer science and another discipline are encouraged; however, a core of computer science courses is required. Courses not labeled CMSC must show relevance to the student's program of study and must be submitted for approval by the dissertation adviser. The advisory committee will conduct an annual review of student progress, with written minutes of committee recommendations prepared by student and signed by all advisory committee members.

The detailed requirements depend on the student's academic background.

Students with an M.S. in Computer Science or in a closely related field must take a minimum of 12 credit hours of didactic course work at the

of the required three comprehensive exam areas must retake the exam in the failed area within the following year. The department may organize and schedule, no earlier than 60 days after the failed exam, a special comprehensive exam for such students. A student who fails two or more exam areas must retake the entire comprehensive exam at the regularly scheduled comprehensive exam within the following year.

- Graduate students may not take the comprehensive exam if their overall GPA falls below the minimum of 3.0.

Oral comprehensive examination

The oral examination (proposal defense), which follows only after successful completion of the qualifying examination, is administered to assess the ability of the student to integrate information and display an appropriate mastery of problem-solving capabilities. The student is required to prepare a written proposal of original research and to defend it in front of the dissertation committee.

Admission to candidacy

Before admission to doctoral candidacy, students must have:

1. Completed required course work (students who entered the program through the B.S. entry point may be admitted to candidacy with six credit hours of electives not completed yet)
2. Successfully completed the comprehensive examinations

Dissertation research

The student must conduct a substantial original investigation under the supervision of the permanent adviser and prepare a dissertation reporting the results of this research and analyzing its significance in relation to existing scientific knowledge. There should be a student advisory committee meeting no later than three months prior to dissertation defense to certify student readiness to write, and this should be signed by all advisory committee members. When the dissertation has been completed, copies in accepted form and style are submitted to the members of the advisory committee.

Final dissertation defense

If the advisory committee accepts the dissertation for defense, the candidate appears before them for a final oral examination. This examination is open to all members of the faculty and students.

Since the Ph.D. is awarded for completion of work on an original research problem, peer-reviewed evidence of the quality of this work, in terms of at least one accepted journal paper or published high-quality conference paper (publications should be in a student's research area), must be approved by the dissertation committee and the graduate committee before the final oral examination can be scheduled. Specific publication requirements are available at the computer science department website as well as in the College of Engineering graduate handbook.

The final oral examination will be limited to the subject of the candidate's dissertation and related matters. A favorable vote of the candidate's advisory committee and no more than one negative vote shall be required for passing the final oral examination. All committee members must vote. There shall be an announcement of the candidate's name, department and title of dissertation, together with the day, place and hour of the final oral examination at least 10 working days in advance.

Curriculum requirements

B.S. to Ph.D. curriculum

Course	Title	Hours
Concentration component		
This component allows the student to pursue a series of courses that focus on a specific field of engineering and serve as the student's primary engineering discipline.		
Foundational area: theory		
CMSC 501	Advanced Algorithms (required)	3
Select at least one of the following:		3
CMSC 510	Regularization Methods for Machine Learning	
CMSC 512	Advanced Social Network Analysis and Security	
CMSC 526	Theory of Programming Languages	
CMSC 591	Topics in Computer Science ¹	
CMSC 601	Convex Optimization	
CMSC 620	Applied Cryptography	
CMSC 621	Theory of Computation	
CMSC 630	Image Analysis	
CMSC 678	Statistical Learning and Fuzzy Logic Algorithms	
CMSC 691	Special Topics in Computer Science ¹	
Foundational area: systems		
Select at least two of the following:		6
CMSC 502	Parallel Algorithms	
CMSC 506/ EGRE 526	Computer Networks and Communications	
CMSC 525	Introduction to Software Analysis, Testing and Verification	
CMSC 591	Topics in Computer Science ¹	
CMSC 603	High Performance Distributed Systems	
CMSC 605	Advanced Computer Architecture	
CMSC 608	Advanced Database	
CMSC 615	Cryptocurrency and Blockchain Techniques	
CMSC 618	Database and Application Security	
CMSC 622	Network and Operating Systems Security	
CMSC 628	Mobile Networks: Applications, Modeling and Analysis	
CMSC 691	Special Topics in Computer Science ¹	
Foundational area: applied computer science		
Select at least two of the following:		6
CMSC 516	Advanced Natural Language Processing	
CMSC 591	Topics in Computer Science ¹	
CMSC 610	Algorithmic Foundations of Bioinformatics	
CMSC 612	Game Theory and Security	
CMSC 623	Cloud Computing	
CMSC 635	Knowledge Discovery and Data Mining	
CMSC 636	Artificial Neural Networks and Deep Learning	

CMSC 691	Special Topics in Computer Science ¹	
Additional CMSC course work, other engineering or science courses		15
Note: At least 17 credit hours of all courses must be at the 600 level or greater.		
Directed research component		
This component emphasizes research directed toward completion of degree requirements under the direction of an adviser and advisory committee.		
CMSC 697	Directed Research	18
Additional course work or directed research		9
Total Hours		60

For these students, the minimum total of graduate credit hours required for this degree is 60.

M.S. to Ph.D. curriculum

Course	Title	Hours
Concentration component		
This component allows the student to pursue a series of courses that focus on a specific field of engineering and serve as the student's primary engineering discipline.		
Foundational area: theory		
Select at least one of the following:		3
CMSC 501	Advanced Algorithms	
CMSC 510	Regularization Methods for Machine Learning	
CMSC 512	Advanced Social Network Analysis and Security	
CMSC 526	Theory of Programming Languages	
CMSC 591	Topics in Computer Science ¹	
CMSC 601	Convex Optimization	
CMSC 620	Applied Cryptography	
CMSC 621	Theory of Computation	
CMSC 630	Image Analysis	
CMSC 678	Statistical Learning and Fuzzy Logic Algorithms	
CMSC 691	Special Topics in Computer Science ¹	
Foundation area: systems		
Select at least one of the following:		3
CMSC 502	Parallel Algorithms	
CMSC 506/ EGRE 526	Computer Networks and Communications	
CMSC 525	Introduction to Software Analysis, Testing and Verification	
CMSC 591	Topics in Computer Science ¹	
CMSC 603	High Performance Distributed Systems	
CMSC 605	Advanced Computer Architecture	
CMSC 608	Advanced Database	
CMSC 615	Cryptocurrency and Blockchain Techniques	
CMSC 618	Database and Application Security	
CMSC 622	Network and Operating Systems Security	

CMSC 628	Mobile Networks: Applications, Modeling and Analysis	
CMSC 691	Special Topics in Computer Science ¹	
Additional CMSC course work, other engineering or science courses		6
Note: At least six credit hours of all courses must be at the 600 level or greater.		
Directed research component		
This component emphasizes research directed toward completion of degree requirements under the direction of an adviser and advisory committee.		
CMSC 697	Directed Research	18
Total Hours		30

¹

Only selected sections of CMSC 591 and CMSC 691 count toward individual foundational areas. An up-to-date list of sections of these topics courses, including their assignments to foundational areas, is available at computer-science.egr.vcu.edu/graduate/computer-science.

For these students, the minimum total of graduate credit hours required for this degree is 30.

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Program website: computer-science.egr.vcu.edu/graduate (<https://egr.vcu.edu/departments/computer/academics/graduate/>)