ENGIEERING, 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, academia 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 Graduate study section for additional information on academic regulations for graduate students (http://bulletin.vcu.edu/graduate/study/general-academic-regulations-graduate-students)

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 Graduate study section for additional information on degree candidacy requirements (http://bulletin.vcu.edu/graduate/study/general-academic-regulations-graduate-students/degree-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 Graduate study section for additional information on graduation requirements (http://bulletin.vcu.edu/graduate/study/general-academic-regulations-graduate-students/graduation-requirements)

Other information

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

Apply online at graduate.admissions.vcu.edu (http://graduate.admissions.vcu.edu).

Admission requirements

<table>
<thead>
<tr>
<th>Degree:</th>
<th>Semester(s) of entry:</th>
<th>Deadline dates:</th>
<th>Test requirements:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ph.D.</td>
<td>Fall</td>
<td>Jun 1 (Jan 15 for financial assistance)</td>
<td>GRE-General</td>
</tr>
</tbody>
</table>
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 School 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/graduate/study/general-academic-regulations-graduate-students/graduation-requirements), students must meet the following requirements.

A minimum of 60 credit hours beyond the bachelor’s degree, or 30 credits beyond a master’s degree, including research credits, is required for the Ph.D. in Engineering.

A minimum of three years of study, including research, is necessary to complete all requirements for the Ph.D. A period of residence of at least three consecutive semesters is required. Residency is defined as registration for at least nine credits per semester. A time limit of seven 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. No credits may be used for both M.S. and Ph.D. degrees.

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 M.S. in Computer Science must take a minimum of 12 credit hours of didactic course work at the 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.

Students admitted into the Ph.D. program 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 these courses.)
  - At least 17 credits at the 600 level or greater

In addition, a student admitted to this program may need to take other undergraduate computer science courses in order to prepare for the required graduate-level courses. The choice of these courses will be left to the discretion of the student’s adviser.

A minimum of 18 credits of directed research is required.

Students admitted into the Ph.D. program without an M.S. in Computer Science must take a minimum of a minimum of 36 credit hours of course work.

- A minimum of 18 didactic credits, including
  - A minimum of two courses from each of the following two foundational areas: theory and systems (CMSC 501 must be one of these courses.)
  - At least nine credits at the 600 level or greater

In addition, a student admitted to this program may need to take other undergraduate computer science courses in order to prepare for the required graduate-level courses. The choice of these courses will be left to the discretion of the student’s adviser.

A minimum of 18 credits of directed research is required.

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.
before the final oral examination can be scheduled. Specific publication approved by the dissertation committee and the graduate committee paper (publications should be in a student’s research area), must be at least one accepted journal paper or published high-quality conference problem, peer-reviewed evidence of the quality of this work, in terms of Since the Ph.D. is awarded for completion of work on an original research examination is open to all members of the faculty and students. If the advisory committee accepts the dissertation for defense, 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 School 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

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

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>CMSC 501</td>
<td>Advanced Algorithms (required)</td>
<td>3</td>
</tr>
<tr>
<td>Select at least one of the following:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CMSC 526</td>
<td>Theory of Programming Languages</td>
<td>3</td>
</tr>
<tr>
<td>CMSC 620/CISS 624</td>
<td>Applied Cryptography</td>
<td></td>
</tr>
<tr>
<td>CMSC 621</td>
<td>Theory of Computation</td>
<td></td>
</tr>
<tr>
<td>CMSC 678</td>
<td>Statistical Learning and Fuzzy Logic Algorithms</td>
<td></td>
</tr>
</tbody>
</table>

Foundational area: systems

Select at least two of the following: 6

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>CMSC 502</td>
<td>Parallel Algorithms</td>
</tr>
<tr>
<td>CMSC 506/EGRE 526</td>
<td>Computer Networks and Communications</td>
</tr>
<tr>
<td>CMSC 605</td>
<td>Advanced Computer Architecture</td>
</tr>
<tr>
<td>CMSC 608</td>
<td>Advanced Database</td>
</tr>
<tr>
<td>CMSC/CISS 618</td>
<td>Database and Application Security</td>
</tr>
<tr>
<td>CMSC 622</td>
<td>Network and Operating Systems Security</td>
</tr>
</tbody>
</table>

Foundational area: applied computer science

Select at least two of the following: 6

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>CMSC/CISS 609</td>
<td>Advanced Computational Intelligence</td>
</tr>
<tr>
<td>CMSC 610</td>
<td>Algorithmic Foundations of Bioinformatics</td>
</tr>
<tr>
<td>CMSC 612</td>
<td>Game Theory and Security</td>
</tr>
<tr>
<td>CMSC 623</td>
<td>Cloud Computing</td>
</tr>
<tr>
<td>CMSC 630</td>
<td>Image Analysis</td>
</tr>
<tr>
<td>CMSC 635</td>
<td>Knowledge Discovery and Data Mining</td>
</tr>
</tbody>
</table>

Options electives component

This component allows the student to take courses in either engineering or science with approval of the student’s adviser.

Additional CMSC course work

Note: At least 15 credit hours of all CMSC 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.

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>CMSC 692</td>
<td>Independent Study</td>
<td>18</td>
</tr>
</tbody>
</table>
Total graduate credit hours required (minimum) 60

M.S. to Ph.D. curriculum

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 (required)
- CMSC 526 Theory of Programming Languages
- CMSC 620/CISS 624 Applied Cryptography
- CMSC 621 Theory of Computation
- CMSC 678 Statistical Learning and Fuzzy Logic Algorithms

Foundation area: systems
Select at least one of the following: 3
- CMSC 502 Parallel Algorithms
- CMSC 506/EGRE 526 Computer Networks and Communications
- CMSC 605 Advanced Computer Architecture
- CMSC 608 Advanced Database
- CMSC/CISS 618 Database and Application Security
- CMSC 622 Network and Operating Systems Security

Options electives component
This component allows the student to take courses in either engineering or science with approval of the student's adviser. 3

Additional CMSC course work, other engineering or science courses 1
Select courses in MATH/OPER/STAT/EGRE (Non-CMSC courses require approval by Graduate Committee.) 3

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 At least six credit hours of all CMSC courses must be at the 600 level or greater. An additional six credit hours is required for students with an M.S. degree in a subject other than computer science.

Total graduate credit hours required (minimum) 30

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