The PhD in Computer Science is designed to prepare students for careers in academia and industry—from conducting research to developing systems to publishing and presenting papers. The rigorous curriculum provides a broad background in the fundamentals of computer science and advanced courses in a wide range of focus areas.

The past decade has witnessed a dramatic increase in Northeastern’s international reputation for research and innovative educational programs. Since 2012, the Khoury College of Computer Sciences has hired 30 outstanding faculty members and plans to continue this strategic growth in the coming years, advancing its position among the nation’s top research universities. Today, the college has a diverse faculty of 62 working in a wide range of research areas. Seventeen faculty members have joint appointments with other colleges and schools, including engineering, science, business, social sciences and humanities, health sciences, and Arts, Media and Design.

Northeastern University is located in the heart of Boston, a city with one of the richest research environments in the world, with over 10,000 researchers, 50,000 graduate students, and a top startup community. Every week there are numerous talks and lectures on cutting-edge research, either at Northeastern or at other universities and research labs easily accessible from Northeastern.

Coursework
A minimum of 48 semester hours of course work beyond the BS/BA degree is required of all students.

All students must demonstrate sufficient knowledge in the fundamentals of computer science, as well as the ability to carry out research in an area of computer science.

The student must maintain a minimum grade-point average (GPA) of 3.500 among the six core courses and receive a grade of B or better in each of these courses. Students who have taken equivalent courses in other institutions may petition to be exempted from the course(s) (subject to the approval of the PhD computer science curriculum committee). Each student may repeat a course once for no more than three out of the six courses if they do not receive a B or better in the course. Students with a Master of Science in Computer Science may petition to the PhD computer science curriculum committee for an exemption from these courses. Petition forms are available on the college website.

The fields listed do not necessarily represent areas of specialization or separate tracks within the PhD program. Rather, they attempt to delineate areas on which the student must be examined in order to measure his or her ability to complete the degree. Therefore, they may be adjusted in the future to reflect changes in the discipline of computer science and in faculty interests within the Khoury College of Computer Sciences. Similarly, these fields do not represent the only areas in which a student may write his or her dissertation. They are, however, intended to serve as a basis for performing fundamental research in computer science.

Paper Requirement
To demonstrate research ability, the student is required to submit to the PhD committee a research or a survey paper in an area of specialty under the supervision of a faculty advisor. A submitted paper from a student is considered to have fulfilled the paper requirement if:

1. The paper has been accepted by a selective conference.
2. The student has made a substantial contribution to the paper.
3. The advisor has endorsed the paper with a written statement indicating the student’s contribution.
4. The PhD computer science curriculum committee has voted on a positive recommendation. The committee may require a presentation from the student before making a recommendation.

Admission to Candidacy
Upon completion of the course and the research paper requirements, the student is admitted to candidacy for the PhD degree. It is highly recommended that the student complete the candidacy requirement by the end of his or her second year but no later than the third year.

Residency
One year of continuous full-time study is required after admission to the PhD candidacy. It is expected that during this period the student will make substantial progress in preparing for the comprehensive examination.

Teaching Requirement
All computer science PhD students must satisfy the teaching requirement in order to graduate. This requirement is fulfilled when the student works as a teaching assistant (TA) or instructor of record (IoR) for one semester and during this semester:

• Teaches at least 3 hours of classes
• Prepares at least one assignment, or quiz, or equivalent

PhD students are expected to satisfy the teaching requirement some time after completing their first year and at least one semester prior to scheduling their PhD defense.

Comprehensive Examination/Dissertation Proposal
After the student has achieved sufficient depth in a field of study, they prepare a proposal for the PhD dissertation. This process should take place no later than the end of the fifth year in residence. The student prepares a dissertation proposal, which describes the proposed research, including the relevant background materials from the literature. The proposal should clearly specify the research problems to be attacked, the techniques to be used, and a schedule of milestones toward completion.

The dissertation proposal must be approved by the dissertation committee. With the help of the advisor, a student selects the committee, consisting of at least four members, to be approved by the PhD computer science curriculum committee. The four members must include the advisor, two internal members, and an external member.

Upon approval of the written proposal, the student has to present the proposed work orally in a public forum, followed by a closed-door oral examination from the dissertation committee. The student may take the dissertation proposal examination twice, at most.

Doctoral Dissertation
Upon successful completion of solving the research proposed in the dissertation proposal, the candidate has an opportunity to prepare the dissertation for approval by the dissertation committee. The dissertation must contain results of extensive research and make an original contribution to the field of computer science. The work should give
evidence of the candidate’s ability to carry out independent research. It is expected that the dissertation should be of sufficient quality to merit publication in a reputable journal in computer science.

**Doctoral Committee**

With the help of the advisor, a student selects the committee, consisting of at least four members, to be approved by the PhD computer science curriculum committee. The four members must include the advisor, two internal members, and an external member.

**Dissertation Defense**

The dissertation defense is held in accordance with the regulations of the University Graduate Council. It consists of a lecture given by the candidate on the subject matter of the dissertation. This is followed by questions from the dissertation committee and others in attendance concerning the results of the dissertation as well as any related matters. The defense is chaired by the PhD advisor.

**Time and Time Limitation**

After the establishment of degree candidacy, a maximum of five years will be allowed for the completion of the degree requirements, unless an extension is granted by the college graduate committee.

**Learning Outcomes**

Students graduating with a PhD in Computer Science must:

- Gain a broad understanding of computer science fundamentals, spanning a substantial portion of the following core areas: artificial intelligence and data science, human-centered computing, software, systems, and theory
- Gain significant expertise in at least one research area in computer science
- Produce and defend original research in an area of computer science
- Be able to communicate research results effectively in both oral and written forms

**Program Requirements**

Complete all courses and requirements listed below unless otherwise indicated.

**Milestones**

Course work
Paper requirement
Admission to candidacy
Residency
Teaching requirement
Comprehensive examination/dissertation proposal
Doctoral dissertation
Doctoral committee
Dissertation defense

**Core Requirements**

A grade of B or higher is required in each course. A cumulative 3.500 GPA is required for the core requirement.

Students should refer to the course numbering table for graduate course leveling (http://catalog.northeastern.edu/graduate/academic-policies-procedures/records-transcripts/).

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Breadth Areas</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Complete one course from four of the five following breadth areas:</td>
<td>16</td>
</tr>
</tbody>
</table>

**Artificial Intelligence and Data Science**

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS 6140</td>
<td>Machine Learning</td>
</tr>
<tr>
<td>CS 7150</td>
<td>Deep Learning</td>
</tr>
<tr>
<td>CS 7200</td>
<td>Statistical Methods for Computer Science</td>
</tr>
<tr>
<td>CS 7240</td>
<td>Principles of Scalable Data Management: Theory, Algorithms, and Database Systems</td>
</tr>
</tbody>
</table>

**Human-Centered Computing**

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS 7340</td>
<td>Theory and Methods in Human Computer Interaction</td>
</tr>
<tr>
<td>CS 7250</td>
<td>Information Visualization: Theory and Applications</td>
</tr>
</tbody>
</table>

**Software**

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS 6410</td>
<td>Compilers</td>
</tr>
<tr>
<td>CS 7400</td>
<td>Intensive Principles of Programming Languages</td>
</tr>
<tr>
<td>CS 7430</td>
<td>Formal Specification, Verification, and Synthesis</td>
</tr>
</tbody>
</table>

**Systems**

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS 7600</td>
<td>Intensive Computer Systems</td>
</tr>
<tr>
<td>CS 7610</td>
<td>Foundations of Distributed Systems</td>
</tr>
</tbody>
</table>

**Theory**

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS 7800</td>
<td>Advanced Algorithms</td>
</tr>
<tr>
<td>CS 7805</td>
<td>Theory of Computation</td>
</tr>
</tbody>
</table>

**Specialization Courses**

Complete 8 semester hours from the specialization course lists. (p. 2) 8

**Electives**

Complete 24 semester hours in the following: 24

Note: Consult faculty advisor for the other acceptable courses.

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
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</thead>
<tbody>
<tr>
<td>CS 5100 to CS 5850, except CS 5340</td>
<td></td>
</tr>
<tr>
<td>CS 6110 to CS 6810</td>
<td></td>
</tr>
<tr>
<td>CS 7340</td>
<td>Theory and Methods in Human Computer Interaction</td>
</tr>
<tr>
<td>CS 8982</td>
<td>Readings</td>
</tr>
</tbody>
</table>

**Dissertation**

Upon achieving PhD candidacy, complete the following courses for two consecutive semesters:

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS 9990</td>
<td>Dissertation Term 1</td>
</tr>
<tr>
<td>CS 9991</td>
<td>Dissertation Term 2</td>
</tr>
</tbody>
</table>

For remaining semester(s), complete the following (repeatable) course until graduation:

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS 9996</td>
<td>Dissertation Continuation</td>
</tr>
</tbody>
</table>

**Specialization Course Lists**

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
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<tbody>
<tr>
<td>CS 5100</td>
<td>Foundations of Artificial Intelligence</td>
</tr>
<tr>
<td>CS 5335</td>
<td>Robotic Science and Systems</td>
</tr>
<tr>
<td>CS 6120</td>
<td>Natural Language Processing</td>
</tr>
</tbody>
</table>
Computer Science, PhD

**CS 6140**  Machine Learning
**CS 7140**  Advanced Machine Learning
**CS 7180**  Special Topics in Artificial Intelligence

**Computer-Human Interface**
**CS 5520**  Mobile Application Development
**CS 6350**  Empirical Research Methods
**CS 7260**  Visualization for Network Science
**CS 7295**  Special Topics in Data Visualization
**CS 7340**  Theory and Methods in Human Computer Interaction

**Data Science**
**CS 5200**  Database Management Systems
**CS 6140**  Machine Learning
**CS 6200**  Information Retrieval
**CS 6220**  Data Mining Techniques
**CS 6240**  Large-Scale Parallel Data Processing
**CS 7140**  Advanced Machine Learning
**CS 7280**  Special Topics in Database Management
**CS 7290**  Special Topics in Data Science

**Graphics**
**CS 5310**  Computer Graphics
**CS 5330**  Pattern Recognition and Computer Vision

**Information Security**
**CS 6760**  Privacy, Security, and Usability
**CS 7580**  Special Topics in Software Engineering
**CS 7810**  Foundations of Cryptography
**CY 5770**  Software Vulnerabilities and Security
**CY 6740**  Network Security
**CY 6750**  Cryptography and Communications Security

**Networks**
**CS 5700**  Fundamentals of Computer Networking
**CS 6710**  Wireless Network
**CS 6760**  Privacy, Security, and Usability
**CS 7775**  Seminar in Computer Security
**CS 7780**  Special Topics in Networks
**CY 6740**  Network Security
**CY 6750**  Cryptography and Communications Security

**Programming Languages**
**CS 5400**  Principles of Programming Language
**CS 6410**  Compilers
**CS 6510**  Advanced Software Development
**CS 7400**  Intensive Principles of Programming Languages
**CS 7480**  Special Topics in Programming Language
**CS 7485**  Special Topics in Formal Methods

**Software Engineering**
**CS 5610**  Web Development
**CS 6510**  Advanced Software Development
**CS 7580**  Special Topics in Software Engineering

**Systems**
**CS 6620**  Fundamentals of Cloud Computing
**CS 6650**  Building Scalable Distributed Systems
**CS 7600**  Intensive Computer Systems
**CS 7610**  Foundations of Distributed Systems
**CS 7680**  Special Topics in Computer Systems
**CY 6740**  Network Security

**Theory**
**CS 6800**  Application of Information Theory
**CS 7485**  Special Topics in Formal Methods
**CS 7800**  Advanced Algorithms
**CS 7805**  Theory of Computation
**CS 7880**  Special Topics in Theoretical Computer Science
**CY 6750**  Cryptography and Communications Security

**Game Design**
**CS 5150**  Game Artificial Intelligence
**CS 5310**  Computer Graphics
**CS 5340**  Computer/Human Interaction
**CS 5850**  Building Game Engines
**CS 7140**  Advanced Machine Learning

**Program Credit/GPA Requirements**
48 total semester hours required
Minimum overall 3.000 GPA required

**Plan of Study**

**Sample Curriculum**

**Year 1**

<table>
<thead>
<tr>
<th>Fall</th>
<th>Hours</th>
<th>Spring</th>
<th>Hours</th>
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<tbody>
<tr>
<td>Breadth course</td>
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<td>Breadth course</td>
<td>4</td>
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<tr>
<td>Core elective</td>
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<td>Core elective</td>
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<td>8</td>
<td>8</td>
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**Year 2**

<table>
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<th>Hours</th>
<th>Spring</th>
<th>Hours</th>
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<tbody>
<tr>
<td>Breadth course</td>
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<td>Breadth course</td>
<td>4</td>
</tr>
<tr>
<td>Open elective</td>
<td>4</td>
<td>Open elective</td>
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<tr>
<td>8</td>
<td>8</td>
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</table>

**Year 3**

<table>
<thead>
<tr>
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<th>Hours</th>
<th>Spring</th>
<th>Hours</th>
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<tr>
<td>CS 9990</td>
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<td>CS 9991</td>
<td>0</td>
</tr>
<tr>
<td>CS 8982</td>
<td>8</td>
<td>CS 8982</td>
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**Year 4**

<table>
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<tr>
<th>Fall</th>
<th>Hours</th>
<th>Spring</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS 9996</td>
<td>0</td>
<td>CS 9996</td>
<td>0</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Year 5**

<table>
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<th>Fall</th>
<th>Hours</th>
<th>Spring</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS 9996</td>
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<td>CS 9996</td>
<td>0</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Advanced Entry PhD Program Requirements
Students with a Master of Science in Computer Science may petition to the PhD CS curriculum committee for an exemption from the core program courses.

Coursework
A minimum of 16 semester hours of course work beyond the master’s degree is required of all students. Completion of the program core courses may also be required and will be determined upon enrollment in the program. Students with a Master of Science in Computer Science may petition to the PhD CS curriculum committee for an exemption from these courses. Petition forms are available on the college website.

Students should work with their faculty advisor on completing required course work. Students must maintain a minimum GPA of 3.500 as well as earn a grade of B or better in each course.

Paper Requirement
Refer to the Computer Science, PhD, overview (p. 1), for research/survey paper requirements.

Admission to Candidacy
Refer to the Computer Science, PhD, overview, (p. 1) for admission to candidacy requirements.

Residency
Refer to the Computer Science, PhD, overview, (p. 1) for residency requirements.

Teaching Requirement
Refer to the Computer Science, PhD, overview, (p. 1) for the teaching requirement.

Comprehensive Examination/Dissertation Proposal
Refer to the Computer Science, PhD, overview, (p. 1) for comprehensive examination requirements.

Learning Outcomes
• Gain a broad understanding of computer science fundamentals, spanning a substantial portion of the following core areas: artificial intelligence and data science, human-centered computing, software, systems, and theory
• Gain significant expertise in at least one research area in computer science
• Produce and defend original research in an area of computer science
• Be able to communicate research results effectively in both oral and written forms

Complete all courses and requirements listed below unless otherwise indicated.

Milestones
Annual review
Course requirements
Paper requirement
Comprehensive exam
Teaching requirement
Doctoral candidacy
Dissertation committee
Dissertation proposal
Dissertation defense

Core Requirements
Students must maintain a minimum GPA of 3.500 as well as earn a grade of B or better in each course.
Consult your faculty adviser for acceptable courses.

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
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</tr>
</thead>
<tbody>
<tr>
<td>CS 9990</td>
<td>Dissertation Term 1</td>
<td></td>
</tr>
<tr>
<td>CS 9991</td>
<td>Dissertation Term 2</td>
<td></td>
</tr>
</tbody>
</table>

Upon achieving PhD candidacy, complete the following (repeatable) course for two consecutive semesters:

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS 8982</td>
<td>Readings</td>
<td></td>
</tr>
</tbody>
</table>

For any remaining semester(s), complete the following (repeatable) course until graduation:

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS 9996</td>
<td>Dissertation Continuation</td>
<td></td>
</tr>
</tbody>
</table>

**Program Credit/GPA Requirements**

16 total semester hours required
Minimum overall 3.500 GPA required