

Computer Science Concentrations

Computer science is a vast field, with many sub-fields each of which having a rich depth of topics well-worth exploring. As a result, one student's computer science degree may look very different from another's, which is great!

To encourage students to be intentional about their course choices, and to allow students who opt to go deep and specialize into a particular sub-field to get that specialization recognized, computer science majors have the opportunity to declare a **concentration** in one of the sub-fields the department recognizes.

Students who successfully complete a concentration will eventually (we're working on it!) have that concentration appear on their transcript, alongside their degree; a good way to signal to potential employers that they have a specific skill set!

Policies

- Concentrations are **optional**; a student may opt not to declare one with no ill effect.
- Students must declare a concentration **by the end of Fall quarter of their Senior year**. It is not necessary to have completed all of the concentration's requirements prior to declaring; completing them prior to graduation is sufficient.
- To complete a concentration, students must take **four (4)** distinct classes from that concentration's course list (see below). These classes may also be counted towards the 21 (19 for Weinberg students) credits of the "Major Program Courses" portion of the CS degree; this is not an additional four classes. Specifically, this means that classes taken to satisfy the Breadth, Project, Technical Electives, and (for McCormick students only) Advanced Electives requirements may also count towards a concentration.
- These 4 courses might count toward any of your degree requirements.
- Students may only declare a **single** concentration. Concentrations signal specialization: we want you to go deep, not to do a cursory survey of multiple areas; that's what the Breadth requirement is for. If you have credits to spare, go deeper!
- Checking for concentration completion happens before graduation, at the same time as checking for other degree requirements.

Frequently Asked Questions

- **Can I declare multiple concentrations?**
No, see above.
- **Can I declare a custom concentration?**
No. The list of concentrations is a list of areas recognized as significant by the CS department, and which have significant external recognition as well.

- **Can I count class X towards concentration Y, even though it's not on the list?**

In almost all cases, no. In rare cases, there may be a new class (i.e., Comp Sci 396/397/496/497) which would be relevant to a concentration, but has not been added yet. In such cases, students should get formal written support from a faculty member in the relevant area, then contact the CS Curriculum Committee

(curriculum@cs.northwestern.edu), CCing the supporting faculty member, to submit a petition. Bear in mind that petitions are likely to be rejected; have a backup plan ready.

- **Will declaring a concentration help me get into the classes for it?**

No. Declaring a concentration does not increase anyone's registration priority, and students pursuing a particular concentration are not more likely to get into the classes for it. If a student cannot take the classes necessary to complete a concentration by the time they graduate, that's too bad; so get started early! Failing to complete a concentration does not jeopardize graduating with a CS major, though; so long as a student satisfies the requirements of the CS major, they're fine there.

List of Concentrations

Students intending to declare a concentration should pick one of the following options. The list of courses which count towards that concentration are listed alongside each one.

Artificial Intelligence

- Comp Sci 296: AI and International Security*
- Comp Sci 301: Introduction to Robotics Laboratory
- Comp Sci 302: Artificial Life
- Comp Sci 325: Artificial Intelligence Programming
- Comp Sci 334: Introduction to Computational Linguistics
- Comp Sci 337: Natural Language Processing
- Comp Sci 338: Practicum in Intelligent Information Systems
- Comp Sci 344: Design of Computer Problem Solvers
- Comp Sci 347/447: Conversational AI
- Comp Sci 348: Introduction to Artificial Intelligence
- Comp Sci 349: Machine Learning
- Comp Sci 353: Natural and Artificial Vision
- Comp Sci 371: Knowledge Representation and Reasoning
- Comp Sci 372/472: Designing and Constructing Models with Multi-Agent Languages
- Comp Sci 374: Causal Graphical Models or Modeling Relationships with Causal Inference
- Comp Sci 396: Declarative Programming for Game AI
- Comp Sci 396: AI for Hybrid, Participatory Narratives
- Comp Sci 396/496: AI and Experimental Narrative
- Comp Sci 397: Seminar in Statistical Language Modeling
- Comp Sci 409: Swarms and Multi-Robot Systems
- Comp Sci 449: Deep Learning
- Comp Sci 454: Computational Optics

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- Comp Sci 461: Deep Learning For Natural Language Processing
- Comp Sci 463: Generative Deep Models
- Comp Sci 469: ML and AI for Robotics
- Comp Sci 474: Probabilistic Graphical Models
- Comp Sci 496: AI Perspectives: Symbolic Reasoning to Deep Learning
- Comp Sci 496: Logic in AI
- Cog Sci 207: Introduction to Cognitive Modeling*

* while this class does not count as a Technical Elective, McCormick students can count it as an "Advanced Elective".

Systems

- Comp Sci 322: Compiler Construction
- Comp Sci 339: Introduction to Database Systems
- Comp Sci 340: Introduction to Networking
- Comp Sci 343: Operating Systems
- Comp Eng 361: Computer Architecture I

Foundations

- Comp Sci 307: Intro to Cryptography
- Comp Sci 332: Online Markets
- Comp Sci 335: Intro to the Theory of Computation
- Comp Sci 336: Design and Analysis of Algorithms
- Comp Sci 362/462: Foundations of Quantum Computing
- Comp Sci 396: Algorithms for Collective Decision Making
- Comp Sci 396/496: Advanced Algorithm Design via Competitive Programming
- Comp Sci 407: Advanced Topics in Modern Cryptography
- Comp Sci 436: Graduate Algorithms
- Comp Sci 437: Approximation Algorithms

Security and Privacy

- Comp Sci 296: AI and International Security*
- Comp Sci 307: Intro to Cryptography
- Comp Sci 308: Foundations of Security
- Comp Sci 312/412: Data Privacy
- Comp Sci 350: Intro to Computer Security
- Comp Sci 354: Computer System Security
- Comp Sci 355: Digital Forensics and Incident Response
- Comp Sci 396: Advanced Offense and Defense in Cybersecurity
- Comp Sci 407: Advanced Topics in Modern Cryptography
- Comp Sci 450: Internet Security
- Comp Sci 496: Engineering Modern Cryptographic Protocols

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Software Engineering and Programming Languages

- Comp Sci 303: Full Stack Software Engineering
- Comp Sci 310: Scalable Software Architectures
- Comp Sci 320: Proving Properties of Programs with Mechanized Logic
- Comp Sci 321: Programming Languages
- Comp Sci 322: Compilers
- Comp Sci 323: Code Analysis and Transformation
- Comp Sci 324: Dynamics of Programming Languages
- Comp Sci 380: Software Quality Engineering
- Comp Sci 387: Responsible Software Engineering
- Comp Sci 388: Software Engineering Beyond Programming
- Comp Sci 392: Rapid Prototyping
- Comp Sci 393: Software Construction
- Comp Sci 394: Agile Software development

Robotics

- Comp Sci 301: Introduction to robotics laboratory
- Comp Sci 302: Artificial life
- Comp Sci 353: Natural and artificial vision
- Comp Sci 409: Swarms and multi-robot systems
- Comp Sci 410: Quadrotor design and control
- Comp Sci 469: Machine learning and artificial intelligence for robotics
- Mech Eng 333: Introduction to mechatronics*
- Mech Eng 433: Advanced mechatronics*
- Mech Eng 449: Robotic manipulation*
- Mech Eng 455: Active learning in robotics*
- Mech Eng 496: Soft robotics*

* while this class does not count as a Technical Elective, McCormick students can count it as an "Advanced Elective".

Computer Hardware and Architecture

- Comp Sci 346: Microcontroller System Design
- Comp Eng 303: Advanced Digital Design
- Comp Eng 361: Computer Architecture I
- Comp Eng 362: Computer Architecture Project
- Comp Eng 452: Advanced Computer Architecture
- Comp Eng 456: Modern Topics in Architecture
- Comp Eng 459: VLSI Algorithmics

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Human-Computer Interaction

- Comp Sci 311: Inclusive Making
- Comp Sci 313: Tangible Interaction Design and Learning
- Comp Sci 314: Technology and Human Interaction
- Comp Sci 315: Design, Technology and Research (Two credits of CS 315 may count toward the HCI concentration)
- Comp Sci 329: HCI Studio
- Comp Sci 330: Human Computer Interaction
- Comp Sci 333: Interactive Information Visualization
- Comp Sci 341 - Social Network Analysis
- Comp Sci 352: Machine Perception of Music & Audio
- Comp Sci 353: Natural and Artificial Vision
- Comp Sci 397: Transformative Computer Science Education
- Comm St 227: Communication & Technology*
- Comm St 378: Online Communities and Crowds*
- Dsgn 305: Human-Centered Service Design*

* while this class does not count as a Technical Elective, McCormick students can count it as an "Advanced Elective".

Quantum

- **CS 362 Foundations of Quantum Computing and Quantum Information**
- **CS 496 Quantum Systems**
- CS 496 Quantum Computer Applications and Programming
- CS 336 Design and Analysis of Algorithms
- CE 496 FPGA Design for Quantum Control*
- PHYS 339-2 Quantum Mechanics*

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Classes in **bold** are especially recommended.