Transformer AI

The AI Engineer

A Book

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# Introduction

“The AI Engineer”. A re-stating of classical principles to bring about a skill-set ready for a new era in technology.

## Curriculum Outline

**CS + Math + ML + Data Science**

* Computer Science
  + Data Structures and Algorithms
  + Systems Programming
  + Operating Systems
  + Compiler Construction
  + Databases
  + Software-Hardware Interface (How to take advantage of a heterogeneous hardware architecture environment)
  + Theoretical Computer Science
    - Theory of Computation
    - Computational Complexity
  + Networking
  + Datacenter Systems and Operations
  + Distributed Computing
* Mathematical Foundations
  + Logic and Reasoning
  + Algebra, Geometry, Trigonometry
  + Pre-Calculus, Calculus
  + Linear Algebra
  + Statistics & Probability
* Machine Learning
  + Neural Networks
  + Application Domains
    - Computer Vision
    - Natural Language Processing
* Data Science
* Data Pipelining/Data Management
* Extra Credit
  + Fundamentals of Engineering
    - Chemistry
    - Engineering Mechanics (Mechanics)
* Libraries & Platforms
  + Mathematics
    - Num-Py
    - Sym-Py
    - Pandas

# Machine Learning

## Neural Networks

### Principles of Operation

### Types of Neural Networks

### Coding from Scratch

## Application Domains

### Computer Vision

### Natural Language Processing

# Appendix A – UW Computer Science Curriculum

## Program of Study: Major: Computer Science

**Program Overview**  
CSE offers two undergraduate degrees: Computer Science (through the College of Arts and Sciences) and Computer Engineering (through the College of Engineering). Students working toward either degree have the same broad opportunities to take the wide array of courses that CSE offers. The Computer Science major may be more appropriate for students who are primarily interested in the design of software systems and applications, or who want to earn a double major with another College of Arts and Sciences program.

This program of study leads to the following credentials:

* Bachelor of Science degree with a major in Computer Science
* Bachelor of Science degree with a major in Computer Science: Data Science

**Completion Requirements**

77-81 Credits

1. *Science (5 credits):* 5 credits from the list of approved natural science courses for Computer Science on the Allen School website.
2. *Mathematics (15-18 credits) complete one of the following:*
   1. MATH 124, MATH 125, MATH 126, MATH 208
   2. MATH 134, MATH 135, MATH 136
3. *Fundamental Courses (24-25 credits):* CSE 123 or CSE 143, CSE 311, CSE 312, CSE 331, CSE 332, CSE 351. Minimum 2.0 grade in each course.
4. *Core and Electives:* 33 additional 300-level and 400-level credits as follows:
   1. Six courses from the CSE Core Courses list on the Allen School website of which at least four courses must be 400-level CSE courses.
   2. Either one additional course from the CSE Core Courses list or one course from the CSE Capstone list on the Allen School website.
   3. Additional courses from the CSE Electives list (which includes the CSE Core Courses list) on the Allen School website to bring the total for core and electives to 33 credits.
5. Minimum 2.00 cumulative GPA in all CSE courses.

## Bachelor of Science degree with a major in Computer Science: Data Science

**Credential Overview**

Computer Science and Engineering (CSE) offers two undergraduate degrees: Computer Science (through the College of Arts & Sciences) and Computer Engineering (through the College of Engineering). Students working toward either degree have the same broad opportunities to take the wide array of courses that CSE offers. The Computer Science major may be more appropriate for students who are primarily interested in the design of software systems and applications, or who want to earn a double major with another College of Arts & Sciences program. Students in Computer Science may also decide to pursue a data science option.

**Completion Requirements**

77-81 Credits

1. *Science (5 credits):* 5 credits from the list of approved natural science courses for Computer Science on the Allen School website.
2. *Mathematics (15-18 credits) complete one of the following:*
   1. MATH 124, MATH 125, MATH 126, MATH 208
   2. MATH 134, MATH 135, MATH 136
3. *Fundamental Courses (24-25 credits):*   
   CSE 123 or CSE 143, CSE 311, CSE 312, CSE 331, CSE 332, CSE 351.   
   Minimum 2.0 grade in each course.
4. *Core and Electives:* 33 additional 300-level and 400-level credits as follows:
   1. Six courses from the CSE Core Courses list on the Allen School website of which at least four courses must be 400-level CSE courses.
   2. Either one additional course from the CSE Core Courses list or one course from the CSE Capstone list on the Allen School website.
   3. Additional courses from the CSE Electives list (which includes the CSE Core Courses list) on the Allen School website to bring the total for core and electives to 33 credits.
5. Minimum 2.00 cumulative GPA in all CSE courses.

**Additional Completion Requirements**

Additional credits required for the Data Science Option increase total major requirements to 80-86 credits. Requirements #1 and #3 below also apply toward the *Core and Electives* major requirement #4 shown above.

1. CSE 421, CSE 442, CSE 444, CSE 446 (15 credits)
2. SOC 225 (3/5 credits)
3. One additional course from the data science elective list (see the Allen School website for list) (3-4 credits)

**Additional Information**

Student Outcomes and Opportunities

* *Learning Objectives and Expected Outcomes:* The computer science field has a broad base of private- and public-sector jobs suitable for the Bachelor of Science graduate: systems analyst, systems programmer, applications programmer, technical sales and marketing, and hardware or software engineering specialist. In addition, there are jobs for which graduate education may be appropriate: producers and developers of computer systems, and teachers and researchers. The field is also highly valued for practicing entrepreneurship.
* *Instructional and Research Facilities:* Paul G. Allen Center for Computer Science and Engineering includes more than 20,000 square feet of laboratories, nearly 1,000 computer systems, and more than 50 terabytes of storage. Gigabit connectivity is provided to every desktop by more than 60 miles of data cabling, and wireless access is available throughout the building.

The Allen School general-purpose laboratories support the diverse set of hardware and software platforms required for a cutting-edge education in the field. The special-purpose laboratories provide tailored support for activities such as mobile robotics, computer graphics, digital design, motion capture, embedded systems, laser scanning, educational technology, networking, and artificial intelligence.

The Allen Center and Gates Center are two of the finest computer science and computer engineering facilities in the nation. All Allen School students have access to these resources.

* *Honors Options Available:* With College Honors (Completion of Honors Core Curriculum and Departmental Honors); With Honors (Completion of Departmental Honors requirements in the major). See adviser for requirements.
* *Research, Internships, and Service Learning:* Internships and co-op opportunities are available for computer science undergraduates. Refer to department website for more information.
* *Departmental Scholarships:* The Allen School has a limited number of scholarships available to current Allen School majors. Refer to department website for more information.
* *Student Organizations/Associations:* A student chapter of the Association for Computing Machinery (ACM) operates within the Allen School.

## Course Catalog

### CSE Science Course Requirements List

* Physics 116, 162, 121/141
* Chemistry 142, 143 or 145
* Biology 180
* Biology 162 (AP credit)

### CSE Core Courses

* CSE 331 - Software Design & Implementation (4) (\*)
* CSE 333 - Systems Programming (4)
* CSE 340 - Interaction Programming (4)
* CSE 341 - Programming Languages (4)
* CSE 344 - Intro to Data Management (4)
* CSE/EE - 371 Design of Digital Circuits and Systems (5) (\*\*)
* STAT 391 - Probability & Statistics for Computer Science (4)
* CSE 401 - Intro to Compiler Construction (4)
* CSE 402 - Design and Implementation of Domain-Specific Languages (4)
* CSE 403 - Software Engineering (4)
* CSE 421 - Intro to Analysis of Algorithms (3)
* CSE 422 - Toolkit for Modern Algorithms (3)
* CSE 426 - Cryptography (3)
* CSE 427 - Computational Biology (3)
* CSE 431 - Intro to Complexity (3)
* CSE 434 - Quantum Computation (4)
* CSE 440 - Intro to HCI (5)
* CSE 442 - Data Visualization (4)
* CSE 444 - Database Systems Internals (4)
* CSE 446 - Machine Learning (4)
* CSE 447 - Natural Language Processing (4)
* CSE 451 - Intro to Operating Systems (4)
* CSE 452 - Distributed Systems (4)
* CSE 453 - Data Center Systems (4)
* CSE 455 - Computer Vision (4)
* CSE 457 - Computer Graphics (4)
* CSE 458 - Computer Animation (5)
* CSE 461 - Computer Networks (4)
* CSE 462 - Wireless Communications (4)
* CSE/EE 469 - Computer Architecture I (5)
* CSE/EE 470 - Computer Architecture II (4)
* CSE 473 - Artificial Intelligence (3)
* CSE/EE 474 - Introduction to Embedded Systems (4)
* CSE 478 - Autonomous Robotics (4)
* CSE 484 - Computer Security (4)
* CSE 486 - Synthetic Biology (3)
* CSE 493 - Special Topics Courses (4)

### CSE

* 369 Intro to Digital Design (3)
* Any course on the CSE Core Course List
* Any graded 400-level majors course (includes 498 & 496 but not 499))
* 480 Computer Ethics (2)
* Up to 2 credits max of CSE 301, ENGR 321, General Studies 350 and/or CSE 492.

### AMATH

* 401 - Vector Calculus & Complex Variables (4)
* 402 - Introduction to Dynamical Systems & Chaos (4)
* 403 - Methods for Partial Differential Equations (4)
* 422 - Introduction to Mathematical Biology (3)
* 423 - Mathematical Biology: Stochastic Models (3)
* 483 - High-Performance Scientific Computing (5)

### BIO-EN

* 485 - Computational Bioengineering (4)

### DXARTS/MUSIC

* 460 - Digital Sound (5)
* 461-463 - Digital Sound Synthesis, Digital Sound Processing, Advanced Digital Sound
* Synthesis and Processing (5, 5, 5). Offered jointly with Music 401-403.

### EE

* 331, 332 - Devices and Circuits I & II (5, 5)
* 341 - Discrete Time Linear Systems (5)
* 400-level - Any graded 400-level majors course with the exception of: EE 406, 452-457, 471, 472, 478, and 491.

### ENGR

* 321 - Engineering Internship Education (one credit may count per quarter, up to two credits total)

### GEOG

* 360 - Principles of GIS Mapping (5)
* 460 - GIS Analysis (5)
* 463 - GIS Workshop (5)
* 465 - GIS Database & Programming (5)

### INFO

* 444    Value-Sensitive Design (5) (Effective Autumn 2018, this course will change to INFO 464)
* 446    Advanced Search Engine Systems (5)
* 454    Information Policy: Domestic and Global (5)

### LING

* 472 - Introduction to Computational Linguistics (5)

### MATH

* 307 - Differential Equations (3)
* NOTE: Once Math 307 becomes 207, it will no longer be a CSE senior elective course.
* 318 - Advanced Linear Algebra Tools and Applications (3)
* 334, 335, 336 - Accelerated Advanced Calculus (5,5,5)
* 402, 403, 404 - Introduction to Modern Algebra (3, 3, 3)
* 407 - Linear Optimization (3)
* 408 - Nonlinear Optimization (3)
* 409 - Discrete Optimization (3)
* 414, 415 - Number Theory (3,3)
* 424, 425, 426 - Fundamental Concepts of Analysis (3,3,3)
* 435, 436 - Introduction to Dynamical Systems (3,3)
* 441 - Topology (3)
* 442 - Differential Geometry (3)
* 461, 462 - Combinational Theory (3,3)
* 464, 465, 466 - Numerical Analysis I, II, III (3, 3, 3)

### STAT

* 341, 342 - Introduction to Probability and Statistical Inference I, II (4,4)
* 421 - Introduction to Applied Statistics and Experimental Design (4)
* 391 - Probability and Statistics for Computer Science (also counts as CSE core) (4)

### STAT/MATH

* 395, 396 - Probability II & III (3,3)
* 491 - Introduction to Stochastic Processes (3)

### Computer Engineering Systems Electives

* CSE 401- Introduction to Compiler Construction (4)  
  *- Prerequisites: CSE 332, CSE 351*
* CSE 402 - Design and Implementation of Domain-Specific Languages (4)
* CSE 403 - Software Engineering (4)  
  *- Prerequisites: CSE 331, CSE 332  
  - Recommended: project experience such as CSE 331*
* CSE 444 - Database Systems Internals (4)  
  *- Prerequisites: CSE 332, CSE 344  
  - Recommended: CSE 331 or CSE 333 or substantial software-project experience*
* CSE 451 - Introduction to Operating Systems (4)  
  *- Prerequisites: CSE 332, CSE 333, CSE 351*
* CSE 452 - Introduction to Distributed Systems (4)  
  *- Prerequisites: CSE 332, CSE 333, CSE 451*
* CSE 453 - Data Center Systems (4)  
  *- Prerequisites: CSE 332 and 333; recommended: CSE 451 or 452*
* CSE 461 - Introduction to Computer-Communication Networks (4)  
  *- Prerequisites: CSE 332, CSE 333*
* CSE/EE 474 - Introduction to Embedded Systems (4) OR CSE 466 Software for Embedded Systems (4) \*  
  *- Prerequisites: CSE 333, CSE 352*
* CSE 467 - Advanced Digital Design (4)  
  - Prerequisites: CSE 332, CSE 352
* CSE/EE 469 - Computer Architecture I (5)  
  *- Prerequisites: CSE 369, CSE 143*
* CSE/EE 470 - Computer Architecture II (4)   
  OR CSE 471 Computer Design and Organization (4) \*\*  
  *- CSE 470 Prerequisites: CSE 351, CSE 469*
* CSE 478 Autonomous Robots (4)
* CSE 484 Computer Security (4)  
  *- Prerequisites: CSE 332, CSE 351*
* EE 476 Digital Integrated Circuit Design (5)
* EE 477 VLSI II (5)

### Allen School Courses

Please refer to the Teaching Schedule for information on when these courses will be offered. Undergrads can request a spot in 500-level courses by completing the petition here.

* CSE 480 - Computer Ethics (2) (previously 492 E)
* CSE 580 - Computing for Social Good
* CSE 581 - Computer Ethics
* CSE 590W - Accessibility Research Seminar
* CSE 599M - Foundations of Fairness in Machine Learning

# Appendix B – UW Mathematics Curriculum

# Appendix A – Princton Computer Science Curriculum