

4. Breadth Requirements

The purpose of the Breadth Requirement for the Doctoral program is to ensure that each graduate of the program has adequate knowledge of the core areas in the field of Computer Science. The Breadth Requirements are divided into 3 areas: Mathematical & Theoretical Foundations, Computer Systems, and Artificial Intelligence & Applications. You need to pass 2 subareas within each of the 3 areas. Each of the 6 passes can be achieved in one of three ways:

- Take a breadth course as listed below and earn a letter grade of A- or better in the class(es).
- You can apply for a waiver based on comparable coursework taken elsewhere. If you are waiving coursework, please contact the designated approver and cc: phdstudentservices@cs after filling out the [Ph.D. Breadth Waiver Form](#). The approver may question the student about both the content of the class and their understanding of the material.
- At the discretion of the breadth area approver, a student can successfully complete the exams or portions of the exams of an associated class or any other appropriate evaluation and receive a "Breadth Area Pass". The Breadth Area Pass is determined by the breadth area approver, like past comp pass/fail decisions, but should generally mean work at a level similar to students getting an A- in an associated class.

Approved breadth area courses and approvers are:

- **Area A: Mathematical and Theoretical Foundations**
 - A. Analysis of Algorithms:** CS168, CS261, CS265 ([Moses Charikar](#))
 - B. Theory of Computation and Complexity Theory:** CS154, CS254 ([Omer Reingold](#))
 - C. Numerical Analysis and Convex Optimization:** CS205I, CS334a, EE364a, EE364b ([Ron Fedkiw](#))
 - D. Logic:** CS157, Phil 251, CS258 ([Mike Genesereth](#))
- **Area B: Computer Systems**
 - A. Computer Architecture:** EE180, EE282, EE382E, CS149, CS316 ([Christos Kozyrakis](#))
 - B. Compilers:** CS143, CS243 ([Monica Lam](#))
 - C. Networks:** CS144, CS244, CS244B ([Nick McKeown](#))
 - D. Programming Languages:** CS242, CS358 ([Alex Aiken](#))
 - E. Software Systems:** Approved breadth area courses can be found [here](#)
- **Area C: Artificial Intelligence and Applications**
 - A. Artificial Intelligence:** CS 121, CS221
OR any **TWO** of the following: CS223A, CS224N, CS224W, CS224U, CS227B, CS228, CS229, CS 229M, CS229T, CS231A CS231N, CS234, CS236 CS237A, CS 281 ([Stefano Ermon](#))
 - B. Computational Biology:** CS173A, CS271, CS272, CS274, CS273A , CS273B, CS273C, CS279, CS371, CS373 ([Anshul Kundaje](#))
 - C. Computer Network and Security:** CS155, CS 251, CS255, CS 356 ([Dan Boneh](#))
 - D. Databases:** CS145, CS245, CS246, CS346, CS345, CS347 ([Jure Leskovec](#))
 - E. Graphics:** CS148, CS248, CS348A, CS348B, CS348c CS348E, CS348I, CS 348K, CS 348N ([Doug James](#))
 - F. HCI:** CS147, CS247 A/B/C...series, CS347 ([Michael Bernstein](#))