SYMBOLIC SYSTEMS

Courses offered by the Symbolic Systems Program are listed under the subject code SYMSYS on the web site (http://explorecourses.stanford.edu/CourseSearch/search?view=catalog&subjectCode=SYMSYS). The program is interdisciplinary, focusing on the relationship between natural and artificial systems that represent, process information. The curriculum includes humanistic approaches to questions about language, information, and intelligence, as well as training in science and engineering.

The mission of the program is to prepare majors with the vocabulary, theoretical background, and technical skills needed for study and research at the advanced undergraduate and graduate levels. Most of the courses in SSP are drawn from affiliated departments. Courses designed specifically for the program are aimed at integrating and supplementing topics covered by the department-based offerings. The curriculum includes humanistic approaches to questions about language and intelligence, as well as training in science and engineering.

SSP offers B.S. and M.S. degree programs. Both programs require students to master a common core of required courses and to choose an area of specialization.

Mission of the Undergraduate Program in Symbolic Systems

The undergraduate program in Symbolic Systems is an interdisciplinary program focusing on the relationships between natural and artificial systems that use symbols to communicate and to represent information. The mission of the program is to prepare majors with the vocabulary, theoretical background, and technical skills necessary to research questions about language, information, and intelligence, both human and machine. The curriculum offers a combination of traditional humanistic approaches to these questions as well as a training and familiarity with contemporary developments in the science and technology of computation. Students in the major take courses in cognitive science, computer programming, logic and computational theory, probability, cognitive psychology, philosophy of mind, linguistics, and artificial intelligence. The program prepares students for a variety of careers in the private and public sectors, especially those involving the human-facing sides of information systems/technology, as well as for further study and research in the cognitive and/or information sciences.

Learning Outcomes (Undergraduate)

The program expects its undergraduate majors to be able to demonstrate the following learning outcomes. These learning outcomes are used in evaluating students and the Symbolic Systems Program. Students are expected to demonstrate:

1. ability to apply formal, philosophical, and/or computational analysis to experimental designs and data and vice versa.
2. ability to understand multiple formal, philosophical, and/or computational frameworks and how they are related to each other.
3. ability to map real world problems or observed phenomena onto formal, philosophical and/or computational frameworks and vice versa.

Learning Outcomes (Graduate)

The purpose of the master’s program is to further develop knowledge and skills in Symbolic Systems and to prepare students for a professional career or doctoral studies. This is achieved through completion of courses representing each of the core disciplines of Symbolic Systems as well as an individualized course program in support of the completion of a Master's thesis.

Bachelor of Science in Symbolic Systems

The program offers a Bachelor of Science in Symbolic Systems, as well as a Bachelor of Science with Honors in Symbolic Systems (p. 13) and a Minor in Symbolic Systems (p. 13). A major in Symbolic Systems qualifies as a Science, Technology, Engineering, and Mathematics (STEM) major under the U.S. Department of Homeland Security’s Designated Degree Programs (https://advising.fellows/advising-office-hours/) of the Program; see the calendar of

How to Declare the Major

To declare a major in Symbolic Systems, a student must:

• Be enrolled in or have completed SYMSYS 1 Minds and Machines
• Declare the major in Axess, and have the declaration approved by the program student services officer.
• Submit a preliminary Course Plan (https://symsys.stanford.edu/undergraduates/forms/) form for the major to a declaration interview with one of the Advising Fellows (https://symsys.stanford.edu/undergraduates/advising-fellows/) or with the Associate Director of the Program; see the calendar of Office Hours (https://symsys.stanford.edu/undergraduatesundergradadvising-fellows/advising-office-hours/) on the Symsys website for possible interview times.

Advising

Upon declaration approval, students are assigned to both the Program Director and Associate Director as major advisors. The student must also select and confirm a concentration advisor.

• Declared majors have until the Autumn Quarter of their junior year to select a concentration advisor. Juniors declaring the major must have a concentration advisor confirmed at the time of declaration.
• Any individual with an ongoing institutional appointment at Stanford (listed as such in Chapters 2, 6, or 9 of the Faculty Handbook (https://facultyhandbook.stanford.edu/)) may serve as the concentration advisor. To confirm a concentration advisor after an eligible faculty member has agreed to fill this role, student must send an email message to symsys-sso@stanford.edu and the concentration advisor.
Degree Requirements

The Symbolic Systems major requires completion of:

- The core: a common set of foundations, breadth requirements, and experiential requirements that all students in the program must complete
- An approved concentration: depth in a particular specialization chosen by the student. See a list of Concentrations (p. 4) below.

Students must submit a course plan to the student services officer for Symbolic Systems at least two quarters prior to the planned graduation date, listing courses taken or that will be completed to fulfill the course requirements for the major.

Students must obtain approval for any courses not listed as approved for a major requirement.

All courses taken to fulfill a major requirement for Symbolic Systems must be passed with either a letter grade ('C-' or better for core courses, and a 'D' or above for concentration courses) a no-option pass grade ('S' or its equivalent in the Graduate School of Business, Stanford Law School, or School of Medicine, or in an approved transfer credit course from another institution. A 'CR' cannot be used to fulfill a major requirement for Symbolic Systems. Students who have already completed a required course with a 'CR' grade may file a Replacement Petition to take a course in the same subject area at the same or a higher level in order to avoid having to retake the course.

Unless otherwise stated, each course that is counted for the major must be taken for 3 units or more. Taking a course for 3 units is sufficient unless the requirement specifically states otherwise.

Each course taken for the major may be counted toward at most one required course in either the Core or Concentration (not both), except in cases where double-counting is explicitly allowed.

Students in a dual degree program (http://exploredegrees.stanford.edu/undergraduatedegreesandprograms/#/dual-degrees), students taking a minor, or students in coterminal program (http://exploredegrees.stanford.edu/cotermdegrees/), may not double-count courses towards different degree programs or minors unless a course is an introductory skill requirement (https://symsys.stanford.edu/undergraduateminor-requirements/introductory-skill-requirements/) for both majors.

The program is open to requests to approving courses not listed as options to fulfill major requirements. Consult the student services office for details of this process.

Core

Core requirements are typically completed earlier than a student’s concentration, but the only requirements that impose explicit restrictions on when a course can be completed during a student’s undergraduate career are the gateway and capstone requirements.

Course Requirements

1. Foundations. These courses should be completed early in the major.

<table>
<thead>
<tr>
<th>Units</th>
<th>Syllabus</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td></td>
</tr>
</tbody>
</table>

a. Gateway Course. Must be taken before a major declaration can be approved.

b. Single Variable Calculus. One of the following:
   - MATH 19, MATH 20, and MATH 21 (or MATH 21A): Calculus

10 units of Advanced Placement Calculus credit

Placement by the Mathematics Placement Diagnostic into MATH 20 or MATH 21 and completion of the rest of the series, or into MATH 51

c. Multivariate Systems. One of the following:
   - MATH 51: Linear Algebra, Multivariable Calculus, and Modern Applications
   - MATH 51A: Linear Algebra, Multivariable Calculus, and Modern Applications, ACE

MATH 61CM Modern Mathematics: Continuous Methods

MATH 61DM Modern Mathematics: Discrete Methods

d. Further Study in Multivariate Systems (Optional, but recommended, and may count within some concentrations).
   - One or more of the following courses, which may be needed as preparation for some Core options and other advanced courses in the major.

CME 102 Ordinary Differential Equations for Engineers (and optionally CME 104)

CME 102A Ordinary Differential Equations for Engineers, ACE (and optionally CME 104A, ACE)

ENGR 108 Introduction to Matrix Methods (formerly CME 103)

MATH 52 Integral Calculus of Several Variables

MATH 62DM Modern Mathematics: Discrete Methods

MATH 63CM Modern Mathematics: Continuous Methods

MATH 104 Applied Matrix Theory

MATH 113 Linear Algebra and Matrix Theory

2. Breadth Requirements. One three-quarter sequence of training in each of four methodological areas, plus a Cross-Area Requirement.

a. Philosophical Analysis. Courses that focus on critical, deep questioning, careful reasoning, introspection, and argumentation, and the meaning of intuitions, scenarios, and evidence. Each of the following:
   - An introductory course in the Philosophy Department. One of the following:

Any course listed with a PHIL number (with the exception of PHIL 99/SYMSYS 1)

THINK 69 Emotion

ii. Writing in the Major (WIM) course.

PHIL 80 Mind, Matter, and Meaning

iii. An advanced undergraduate Philosophy course that lists PHIL 80 as a prerequisite. One of the following:

PHIL 107B Plato's Later Metaphysics and Epistemology

PHIL 167D Philosophy of Neuroscience

PHIL 173B Metaethics

PHIL 175 Philosophy of Law

PHIL 180 Metaphysics

PHIL 180A Realism, Anti-Realism, Irrealism, Quasi-Realism

PHIL 181 Philosophy of Language

PHIL 182 Advanced Philosophy of Language

PHIL 182A Naturalizing Representation
<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS 103</td>
<td>Mathematical Foundations of Computing (Corequisite: CS 106B or X)</td>
<td>3-5</td>
</tr>
<tr>
<td>CS 154</td>
<td>Introduction to the Theory of Computation (Prerequisite: CS 103 or significant proof-writing experience.)</td>
<td>3-4</td>
</tr>
<tr>
<td>CME 106</td>
<td>Introduction to Probability and Statistics for Engineers</td>
<td>4</td>
</tr>
<tr>
<td>CS 109</td>
<td>Introduction to Probability for Computer Scientists</td>
<td>3-5</td>
</tr>
<tr>
<td>EE 178</td>
<td>Probabilistic Systems Analysis</td>
<td>3-4</td>
</tr>
<tr>
<td>MATH 151</td>
<td>Introduction to Probability Theory</td>
<td>3</td>
</tr>
<tr>
<td>MATH 63DM</td>
<td>Modern Mathematics: Discrete Methods</td>
<td>5</td>
</tr>
<tr>
<td>MS&amp;E 120</td>
<td>Introduction to Probability</td>
<td>4</td>
</tr>
<tr>
<td>MS&amp;E 220</td>
<td>Probabilistic Analysis</td>
<td>3-4</td>
</tr>
<tr>
<td>STATS 110</td>
<td>Statistical Methods in Engineering and the Physical Sciences</td>
<td>5</td>
</tr>
<tr>
<td>STATS 116</td>
<td>Theory of Probability</td>
<td>4</td>
</tr>
<tr>
<td>CS 107</td>
<td>Computer Organization and Systems</td>
<td>3-5</td>
</tr>
<tr>
<td>CS 107E</td>
<td>Computer Systems from the Ground Up</td>
<td>3-5</td>
</tr>
<tr>
<td>CS 129</td>
<td>Applied Machine Learning</td>
<td>3-4</td>
</tr>
<tr>
<td>CS 147</td>
<td>Introduction to Human-Computer Interaction Design</td>
<td>3-5</td>
</tr>
<tr>
<td>CS 193A</td>
<td>Android Programming</td>
<td>3-4</td>
</tr>
<tr>
<td>CS 193C</td>
<td>Client-Side Internet Technologies</td>
<td>3-5</td>
</tr>
<tr>
<td>CS 193P</td>
<td>iOS Application Development</td>
<td>3-5</td>
</tr>
<tr>
<td>CS 193X</td>
<td>Web Programming Fundamentals</td>
<td>3-5</td>
</tr>
<tr>
<td>CS 194H</td>
<td>User Interface Design Project</td>
<td>3-5</td>
</tr>
<tr>
<td>CS 221</td>
<td>Artificial Intelligence: Principles and Techniques</td>
<td>3-4</td>
</tr>
<tr>
<td>CS 229</td>
<td>Machine Learning</td>
<td>3-4</td>
</tr>
</tbody>
</table>

**d. Empirical Cognitive Science.** Courses that focus on questions, hypotheses, models, predictions, and explanations that are derived from or testable in neural and behavioral data. Each of the following:

- **i. Overview of psychology:**
  - PSYCH 1 Introduction to Psychology | 5
  - PSYCH 45 Introduction to Learning and Memory | 3
  - PSYCH 50 Introduction to Cognitive Neuroscience | 4
  - PSYCH 60 Introduction to Developmental Psychology | 3
  - PSYCH 70 Self and Society: Introduction to Social Psychology | 4
  - PSYCH 75 Introduction to Cultural Psychology | 5
  - PSYCH 141 Cognitive Development | 3

- **ii. An introductory area course in cognition, language, and neuroscience.** One of the following:
  - BIO 150 Human Behavioral Biology | 5
  - LINGUIST 110 Introduction to Phonology | 4
  - LINGUIST 120 Introduction to Syntax | 4
  - LINGUIST 130A Introduction to Semantics and Pragmatics | 4
  - LINGUIST 130B Introduction to Lexical Semantics | 3-4

- **Additional approved undergraduate courses offered on a semi-regular basis:**
  - LINGUIST 21N Linguistic Diversity and Universals: The Principles of Language Structure | 4
  - LINGUIST 30N Linguistic Meaning and the Law | 4
  - LINGUIST 121A The Syntax of English | 4
  - LINGUIST 121B Crosslinguistic Syntax | 4
  - LINGUIST 134A The Structure of Discourse: Theory and Applications | 4
  - LINGUIST 160 Introduction to Language Change | 4

**Cross-Area Requirement:** A non-introductory course, which has as a prerequisite at least one Core course (or equivalent), and which combines methods and subject matter from at least two Breadth areas in the Core. One of the following:

- **i. Suggested courses for most students.** Only one course must be chosen to fulfill the requirement - categories are for guidance only.

  - Philosophical Analysis and Formal Methods
    - PHIL 152 Computability and Logic | 4
    - PHIL 154 Modal Logic | 4
    - PHIL 162 Philosophy of Mathematics | 4
    - PHIL 181 Philosophy of Language | 4
    - Philosophical Analysis and Computational Methods
      - CS 181 Computers, Ethics, and Public Policy | 4
      - CS 182 Ethics, Public Policy, and Technological Change | 5
      - PHIL 152 Computability and Logic | 4
      - PHIL 167D Philosophy of Neuroscience | 4
      - Philosophical Analysis and Empirical Cognitive Science
      - PHIL 167D Philosophy of Neuroscience | 4
      - PHIL 181 Philosophy of Language | 4
      - PHIL 186 Philosophy of Mind | 4

**Stanford Bulletin 2019-20**
### Formal Methods and Computational Methods

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS 151</td>
<td>Logic Programming</td>
<td>3</td>
</tr>
<tr>
<td>CS 154</td>
<td>Introduction to the Theory of Computation</td>
<td>3-4</td>
</tr>
<tr>
<td>CS 161</td>
<td>Design and Analysis of Algorithms</td>
<td>3-5</td>
</tr>
<tr>
<td>CS 229</td>
<td>Machine Learning</td>
<td>3-4</td>
</tr>
<tr>
<td>CS 238</td>
<td>Decision Making under Uncertainty</td>
<td>3-4</td>
</tr>
<tr>
<td>LINGUIST 130A</td>
<td>Introduction to Semantics and Pragmatics</td>
<td>4</td>
</tr>
<tr>
<td>LINGUIST 180</td>
<td>From Languages to Information</td>
<td>3-4</td>
</tr>
<tr>
<td>PHIL 152</td>
<td>Computability and Logic</td>
<td>4</td>
</tr>
<tr>
<td>PHIL 154</td>
<td>Modal Logic</td>
<td>4</td>
</tr>
<tr>
<td>PSYCH 204</td>
<td>Computation and Cognition: The Probabilistic Approach</td>
<td>3</td>
</tr>
<tr>
<td>PSYCH 209</td>
<td>Neural Network Models of Cognition</td>
<td>4</td>
</tr>
<tr>
<td>PSYCH 221</td>
<td>Image Systems Engineering</td>
<td>1-3</td>
</tr>
<tr>
<td>PSYCH 242</td>
<td>Theoretical Neuroscience</td>
<td>3</td>
</tr>
<tr>
<td>PHIL 249</td>
<td>Evidence and Evolution</td>
<td>3-5</td>
</tr>
</tbody>
</table>

### Formal Methods and Empirical Cognitive Science

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>PSYCH 253</td>
<td>Advanced Statistical Modeling</td>
<td>3</td>
</tr>
<tr>
<td>CS 229</td>
<td>Machine Learning</td>
<td>3-4</td>
</tr>
<tr>
<td>ECON 178</td>
<td>Behavioral Economics</td>
<td>5</td>
</tr>
<tr>
<td>LINGUIST 130A</td>
<td>Introduction to Semantics and Pragmatics</td>
<td>4</td>
</tr>
<tr>
<td>LINGUIST 180</td>
<td>From Languages to Information</td>
<td>3-4</td>
</tr>
<tr>
<td>PHIL 154</td>
<td>Modal Logic</td>
<td>4</td>
</tr>
<tr>
<td>PHIL 181</td>
<td>Philosophy of Language</td>
<td>4</td>
</tr>
<tr>
<td>PSYCH 204</td>
<td>Computation and Cognition: The Probabilistic Approach</td>
<td>3</td>
</tr>
<tr>
<td>PSYCH 209</td>
<td>Neural Network Models of Cognition</td>
<td>4</td>
</tr>
<tr>
<td>PSYCH 221</td>
<td>Image Systems Engineering</td>
<td>1-3</td>
</tr>
<tr>
<td>PSYCH 242</td>
<td>Theoretical Neuroscience</td>
<td>3</td>
</tr>
<tr>
<td>PSYCH 249</td>
<td>Large-Scale Neural Network Modeling for Neuroscience</td>
<td>1-3</td>
</tr>
<tr>
<td>PSYCH 253</td>
<td>Advanced Statistical Modeling</td>
<td>3</td>
</tr>
</tbody>
</table>

### Computational Methods and Empirical Cognitive Science

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS 147</td>
<td>Introduction to Human-Computer Interaction Design</td>
<td>3-5</td>
</tr>
<tr>
<td>CS 229</td>
<td>Machine Learning</td>
<td>3-4</td>
</tr>
<tr>
<td>CS 448B</td>
<td>Data Visualization</td>
<td>3-4</td>
</tr>
<tr>
<td>LINGUIST 130A</td>
<td>Introduction to Semantics and Pragmatics</td>
<td>4</td>
</tr>
<tr>
<td>LINGUIST 180</td>
<td>From Languages to Information</td>
<td>3-4</td>
</tr>
<tr>
<td>PHIL 167D</td>
<td>Philosophy of Neuroscience</td>
<td>4</td>
</tr>
<tr>
<td>PSYCH 164</td>
<td>Brain decoding</td>
<td>3</td>
</tr>
<tr>
<td>PSYCH 204</td>
<td>Computation and Cognition: The Probabilistic Approach</td>
<td>3</td>
</tr>
<tr>
<td>PSYCH 209</td>
<td>Neural Network Models of Cognition</td>
<td>4</td>
</tr>
<tr>
<td>PSYCH 221</td>
<td>Image Systems Engineering</td>
<td>1-3</td>
</tr>
<tr>
<td>PSYCH 204A</td>
<td>Human Neuroimaging Methods</td>
<td>3</td>
</tr>
<tr>
<td>PSYCH 242</td>
<td>Theoretical Neuroscience</td>
<td>3</td>
</tr>
<tr>
<td>PSYCH 249</td>
<td>Large-Scale Neural Network Modeling for Neuroscience</td>
<td>1-3</td>
</tr>
<tr>
<td>PSYCH 253</td>
<td>Advanced Statistical Modeling</td>
<td>3</td>
</tr>
</tbody>
</table>

### Experiential Requirements. Each of the following:

**a.** Advanced Small Seminar Requirement. An approved course which (a) builds on the Core Foundations and Breadth Requirements, (b) is small – 20 students or fewer, and (c) is an interactive, discussion-based seminar. May be double-counted for an applicable Concentration requirement, but not for a Core requirement.

**b.** Capstone. A two-course requirement consisting of the following components, chosen in consultation with and approved by a student’s Concentration Advisor (3 or more units each):

- (i) Practicum. A project or internship-accompanying course. One of the following:
  - SYMSYS 190: Senior Honors Tutorial (1-5 units)
  - Symbolic Systems in Practice (must be taken in conjunction with an approved internship or service project)
  - An approved project course with a Symsys listing in the 195-series (may be either the second quarter of a 2-quarter course, or a one-quarter course)

- (ii) Integrative Requirement. Either an additional research project course (e.g., the second course of an Honors Project) or a Concentration-Specific Integrative Course, which must be completed no earlier than the Junior Year. May be applied to a student’s Concentration.

One of the following (the first three bulleted options are the Standard Options available across all Concentrations):

- SYMSYS 190: Senior Honors Tutorial (continuation of the course taken for the Practicum requirement)
- An approved project course with a Symsys listing in the 195-series (may be either the second quarter of a 2-quarter course, or a one-quarter course)
- Supervised research with a faculty member on an approved symbolic-systems related project, taken as SYMSYS 196: Independent Study, or a department-based directed research course.

- An approved Concentration-Specific Integrative Course taken within a Concentration.

**Total Units:** 75-90

### Concentration Areas

Please note: the concentrations areas are being revised, and new ones being added. This section will be fully updated by the opening of class enrollment on September 1, 2020.

### Applied Logic

See also the Symbolic Systems website (https://symsys.stanford.edu/undergraduatesconcentrations/applied-logic-al-concentration/).

#### Units

**Introductory Requirements**

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS 154</td>
<td>Introduction to the Theory of Computation</td>
<td>3-4</td>
</tr>
<tr>
<td>PHIL 151</td>
<td>Metalogic</td>
<td>4</td>
</tr>
<tr>
<td>PHIL 152</td>
<td>Computability and Logic</td>
<td>4</td>
</tr>
</tbody>
</table>

**Computational**

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>PSYCH 204</td>
<td>Computation and Cognition: The Probabilistic Approach</td>
<td>3</td>
</tr>
<tr>
<td>PSYCH 209</td>
<td>Neural Network Models of Cognition</td>
<td>4</td>
</tr>
<tr>
<td>PSYCH 221</td>
<td>Image Systems Engineering</td>
<td>1-3</td>
</tr>
<tr>
<td>PSYCH 204A</td>
<td>Human Neuroimaging Methods</td>
<td>3</td>
</tr>
<tr>
<td>PSYCH 242</td>
<td>Theoretical Neuroscience</td>
<td>3</td>
</tr>
<tr>
<td>PSYCH 249</td>
<td>Large-Scale Neural Network Modeling for Neuroscience</td>
<td>1-3</td>
</tr>
<tr>
<td>PSYCH 253</td>
<td>Advanced Statistical Modeling</td>
<td>3</td>
</tr>
</tbody>
</table>

**Set Theory**

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 161</td>
<td>Set Theory</td>
<td>3</td>
</tr>
</tbody>
</table>

**Formal Semantics**

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>LINGUIST 130A</td>
<td>Introduction to Semantics and Pragmatics</td>
<td>4</td>
</tr>
<tr>
<td>LINGUIST 230B</td>
<td>Advanced Semantics</td>
<td>3</td>
</tr>
<tr>
<td>LINGUIST 230C</td>
<td>Advanced Topics in Semantics &amp; Pragmatics</td>
<td>3-4</td>
</tr>
</tbody>
</table>
Select two of the following:

- PHIL 156A Modal Logics - A Modern Perspective
- PHIL 159 Non-Classical Logic
- PHIL 188W Paradoxes
- PHIL 351 Representation Theorems
- PHIL 351B Proof Mining
- PHIL 351C Formal Methods in Ethics
- PHIL 351D Measurement Theory
- PHIL 353 Seminar on Philosophy of Logic and Mathematics
- PHIL 356 Applications of Modal Logic
- PHIL 356C Logic and Artificial Intelligence
- PHIL 357 Research Seminar on Logic and Cognition
- PHIL 359 Topics in Logic, Information and Agency
- PHIL 391 Seminar on Logic & Formal Philosophy

Note: PHIL 359 counts only if taken for 3 or more units, in accordance with the policy for all core courses.

Total Units: 15-18

### Artificial Intelligence

See also the Symbolic Systems website (https://symsys.stanford.edu/undergraduatesconcentrations/artificial-intelligence-ai-concentration/).

Select five courses from the following six areas:

#### Knowledge Representation and Reasoning

- CS 151 Logic Programming
- CS 157 Computational Logic
- CS 228 Probabilistic Graphical Models: Principles and Techniques
- CS 238 Decision Making under Uncertainty
- PHIL 154 Modal Logic

#### Natural Language Processing

- CS 124 From Languages to Information
- CS 224N Natural Language Processing with Deep Learning
- CS 224S Spoken Language Processing
- CS 224U Natural Language Understanding
- CS 276 Information Retrieval and Web Search
- SYMSYS 112 Challenges for Language Systems

#### Learning

- CS 217 Hardware Accelerators for Machine Learning
- CS 224W Machine Learning with Graphs
- CS 229 Machine Learning
- CS 230 Deep Learning
- CS 234 Reinforcement Learning
- CS 236 Deep Generative Models
- CS 246 Mining Massive Data Sets
- CS 325B Data for Sustainable Development
- EE 104 Introduction to Machine Learning
- MS&E 234 Data Privacy and Ethics
- PSYCH 204 Computation and Cognition: The Probabilistic Approach
- STATS 315A Modern Applied Statistics: Learning
- STATS 315B Modern Applied Statistics: Data Mining

### Robotics and Vision

- CS 131 Computer Vision: Foundations and Applications
- CS 148 Introduction to Computer Graphics and Imaging
- CS 223A Introduction to Robotics
- CS 225A Experimental Robotics
- CS 231A Computer Vision: From 3D Reconstruction to Recognition
- CS 231N Convolutional Neural Networks for Visual Recognition
- CS 234 Reinforcement Learning
- CS 331B Representation Learning in Computer Vision
- CS 333 Algorithms for Interactive Robotics
- CS 348K Visual Computing Systems
- PSYCH 250 High-level Vision: From Neurons to Deep Neural Networks

### Additional Topics

- BIOMEDIN 210 Modeling Biomedical Systems
- BIOMEDIN 214 Representations and Algorithms for Computational Molecular Biology
- CS 227B General Game Playing
- LAW 4039 Regulating Artificial Intelligence
- MS&E 135 Networks
- MUSIC 220B Compositional Algorithms, Psychoacoustics, and Computational Music
- MUSIC 220C Research Seminar in Computer-Generated Music
- PHIL 20N Philosophy of Artificial Intelligence
- PHIL 153L Computing Machines and Intelligence
- PHIL 356C Logic and Artificial Intelligence
- PHIL 357 Research Seminar on Logic and Cognition
- PSYCH 247 Topics in Natural and Artificial Intelligence
- SYMSYS 207 Conceptual Issues in Cognitive Science
- SYMSYS 208 Computer Machines and Intelligence
- SYMSYS 275 Collective Behavior and Distributed Intelligence

### Mathematical Foundations

- CME 263 Introduction to Linear Dynamical Systems
- CS 154 Introduction to the Theory of Computation
- CS 161 Design and Analysis of Algorithms
- CS 168 The Modern Algorithmic Toolbox
- CS 205L Continuous Mathematical Methods with an Emphasis on Machine Learning
- ECON 160 Game Theory and Economic Applications
- EE 263 Introduction to Linear Dynamical Systems
- EE 276 Information Theory
- EE 364A Convex Optimization I
- EE 364B Convex Optimization II
- ENGR 205 Introduction to Control Design Techniques
- ENGR 209A Analysis and Control of Nonlinear Systems
- MATH 104 Applied Matrix Theory
- MATH 113 Linear Algebra and Matrix Theory
- MS&E 251 Introduction to Stochastic Control with Applications
PHIL 152  Computation and Logic

Total Units  15-22

1 Three of the five courses must be chosen from the list below in at least two areas:


Cognitive Science

See also the Symbolic Systems website (https://symsys.stanford.edu/undergraduatesconcentrations/cognitive-science-cogsci-concentration/).

<table>
<thead>
<tr>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cognitive Neuroscience</td>
</tr>
</tbody>
</table>

Select one of the following:

- PSYCH 30  Introduction to Perception
- PSYCH 45  Introduction to Learning and Memory
- PSYCH 50  Introduction to Cognitive Neuroscience
- PSYCH 162  Brain Networks
- PSYCH 164  Brain decoding
- PSYCH 202  Cognitive Neuroscience

<table>
<thead>
<tr>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Empirical Methods</td>
</tr>
</tbody>
</table>

Select one of the following:

- COMM 106  Communication Research Methods
- EE 104  Introduction to Machine Learning
- MS&E 231  Introduction to Computational Social Science
- PSYCH 204A  Human Neuroimaging Methods
- PSYCH 251  Experimental Methods
- PSYCH 252  Statistical Methods for Behavioral and Social Sciences
- PSYCH 253  Advanced Statistical Modeling
- STATS 101  Data Science 101
- STATS 191  Introduction to Applied Statistics
- STATS 200  Introduction to Statistical Inference
- STATS 263  Design of Experiments

Three additional courses chosen across and/or within the following five areas: 9-16

<table>
<thead>
<tr>
<th>Language</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS 224N  Natural Language Processing with Deep Learning</td>
</tr>
<tr>
<td>LINGUIST 110  Introduction to Phonology</td>
</tr>
<tr>
<td>LINGUIST 140  Learning to Speak: An Introduction to Child Language Acquisition</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Perception</th>
</tr>
</thead>
<tbody>
<tr>
<td>LINGUIST 180  From Languages to Information</td>
</tr>
<tr>
<td>LINGUIST 236  Seminar in Semantics: Causation</td>
</tr>
<tr>
<td>LINGUIST 248  Seminar in Developmental Psycholinguistics</td>
</tr>
<tr>
<td>PHIL 181  Philosophy of Language</td>
</tr>
<tr>
<td>PHIL 194D  Capstone Seminar: Artificial Intelligence</td>
</tr>
<tr>
<td>PHIL 194K  Slurs and Derogation: Artificial Intelligence</td>
</tr>
<tr>
<td>PHIL 348  Evolution of Signalling</td>
</tr>
<tr>
<td>PHIL 385D  Advanced Topics in Philosophy of Language</td>
</tr>
<tr>
<td>PSYCH 132  Language and Thought</td>
</tr>
<tr>
<td>PSYCH 140  Introduction to Psycholinguistics</td>
</tr>
<tr>
<td>SYMSYS 112  Challenges for Language Systems</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Higher Cognition</th>
</tr>
</thead>
<tbody>
<tr>
<td>PSYCH 182A  Naturalizing Representation</td>
</tr>
<tr>
<td>PHIL 183  Self-knowledge and Metacognition</td>
</tr>
<tr>
<td>PHIL 184  Topics in Epistemology</td>
</tr>
<tr>
<td>PHIL 185  Special Topics in Epistemology: Testimony in science and everyday life</td>
</tr>
<tr>
<td>PHIL 186  Philosophy of Mind</td>
</tr>
<tr>
<td>PHIL 187  Philosophy of Action</td>
</tr>
<tr>
<td>PHIL 194A  Rationality Over Time</td>
</tr>
<tr>
<td>PHIL 386  Truth as the aim of belief and inquiry</td>
</tr>
<tr>
<td>PHIL 388  Topics in Normativity</td>
</tr>
<tr>
<td>PSYCH 45  Introduction to Learning and Memory</td>
</tr>
<tr>
<td>PSYCH 70  Self and Society: Introduction to Social Psychology</td>
</tr>
<tr>
<td>PSYCH 75  Introduction to Cultural Psychology</td>
</tr>
<tr>
<td>PSYCH 141  Cognitive Development</td>
</tr>
<tr>
<td>PSYCH 154  Judgment and Decision-Making</td>
</tr>
<tr>
<td>PSYCH 160  Seminar on Emotion</td>
</tr>
<tr>
<td>PSYCH 169  Advanced Seminar on Memory</td>
</tr>
<tr>
<td>PSYCH 175  Social Cognition and Learning in Early Childhood</td>
</tr>
<tr>
<td>PSYCH 205  Foundations of Cognition</td>
</tr>
<tr>
<td>PSYCH 266  Current Debates in Learning and Memory</td>
</tr>
<tr>
<td>PSYCH 285  Graduate Seminar on Theory of Mind</td>
</tr>
<tr>
<td>SYMSYS 203  Cognitive Science Perspectives on Humanity and Well-Being</td>
</tr>
</tbody>
</table>

Neuroscience
<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIO 150</td>
<td>Human Behavioral Biology</td>
</tr>
<tr>
<td>CS 234</td>
<td>Reinforcement Learning</td>
</tr>
<tr>
<td>EDUC 266</td>
<td>Educational Neuroscience</td>
</tr>
<tr>
<td>MUSIC 257</td>
<td>Neuroplasticity and Musical Gaming</td>
</tr>
<tr>
<td>NBIO 101</td>
<td>Social and Ethical Issues in the Neurosciences</td>
</tr>
<tr>
<td>NBIO 206</td>
<td>The Nervous System</td>
</tr>
<tr>
<td>NBIO 258</td>
<td>Information and Signaling Mechanisms in Neurons and Circuits</td>
</tr>
<tr>
<td>PHIL 167D</td>
<td>Philosophy of Neuroscience</td>
</tr>
<tr>
<td>PHIL 360</td>
<td>Grad Seminar: Philosophy of Neuroscience</td>
</tr>
<tr>
<td>PSYCH 162</td>
<td>Brain Networks</td>
</tr>
<tr>
<td>PSYCH 164</td>
<td>Brain decoding</td>
</tr>
<tr>
<td>PSYCH 202</td>
<td>Cognitive Neuroscience</td>
</tr>
<tr>
<td>PSYCH 204A</td>
<td>Human Neuroimaging Methods</td>
</tr>
<tr>
<td>PSYCH 204B</td>
<td>Computational Neuroimaging</td>
</tr>
<tr>
<td>PSYCH 209</td>
<td>Neural Network Models of Cognition</td>
</tr>
<tr>
<td>PSYCH 232</td>
<td>Brain and Decision</td>
</tr>
<tr>
<td>PSYCH 248A</td>
<td>fMRI Analysis Bootcamp</td>
</tr>
<tr>
<td>PSYCH 249</td>
<td>Large-Scale Neural Network Modeling for Neuroscience</td>
</tr>
<tr>
<td>PSYCH 251</td>
<td>Experimental Methods</td>
</tr>
<tr>
<td>PSYCH 254</td>
<td>Affective Neuroscience</td>
</tr>
<tr>
<td>PSYCH 287</td>
<td>Brain Machine Interfaces: Science, Technology, and Application</td>
</tr>
<tr>
<td><strong>Theoretical Foundations</strong></td>
<td></td>
</tr>
<tr>
<td>CS 154</td>
<td>Introduction to the Theory of Computation</td>
</tr>
<tr>
<td>ECON 160</td>
<td>Game Theory and Economic Applications</td>
</tr>
<tr>
<td>EE 276</td>
<td>Information Theory</td>
</tr>
<tr>
<td>MATH 113</td>
<td>Linear Algebra and Matrix Theory</td>
</tr>
<tr>
<td>PHIL 82T</td>
<td>Philosophy of Cognitive Science</td>
</tr>
<tr>
<td>PHIL 152</td>
<td>Computability and Logic</td>
</tr>
<tr>
<td>PHIL 153L</td>
<td>Computing Machines and Intelligence</td>
</tr>
<tr>
<td>PHIL 154</td>
<td>Modal Logic</td>
</tr>
<tr>
<td>PHIL 351D</td>
<td>Measurement Theory</td>
</tr>
<tr>
<td>PHIL 356C</td>
<td>Logic and Artificial Intelligence</td>
</tr>
<tr>
<td>PHIL 357</td>
<td>Research Seminar on Logic and Cognition</td>
</tr>
<tr>
<td>PSYCH 204</td>
<td>Computation and Cognition: The Probabilistic Approach</td>
</tr>
<tr>
<td>PSYCH 247</td>
<td>Topics in Natural and Artificial Intelligence</td>
</tr>
<tr>
<td>SYMSYS 202</td>
<td>Theories of Consciousness</td>
</tr>
<tr>
<td>SYMSYS 207</td>
<td>Conceptual Issues in Cognitive Science</td>
</tr>
<tr>
<td>SYMSYS 208</td>
<td>Computer Machines and Intelligence</td>
</tr>
<tr>
<td><strong>Total Units</strong></td>
<td>15-25</td>
</tr>
</tbody>
</table>

### Computer Music

See also the Symbolic Systems website (https://symsys.stanford.edu/undergraduatesconcentrations/computer-music-cm-concentration/).

**Music Fundamentals**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>MUSIC 220A</td>
<td>Fundamentals of Computer-Generated Sound</td>
<td>2-4</td>
</tr>
<tr>
<td>MUSIC 220B</td>
<td>Compositional Algorithms, Psychoacoustics, and Computational Music</td>
<td>2-4</td>
</tr>
</tbody>
</table>

**Music and the Mind & Brain**

Select one of the following:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>MUSIC 1A</td>
<td>Music, Mind, and Human Behavior</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>MUSIC 251</td>
<td>Psychophysics and Music Cognition</td>
</tr>
<tr>
<td>MUSIC 351A</td>
<td>Seminar in Music Perception and Cognition</td>
</tr>
<tr>
<td>PSYCH 30</td>
<td>Introduction to Perception</td>
</tr>
<tr>
<td>PSYCH 50</td>
<td>Introduction to Cognitive Neuroscience</td>
</tr>
</tbody>
</table>

**Music HCI/Design**

3-5

Select one of the following:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS 147</td>
<td>Introduction to Human-Computer Interaction Design</td>
</tr>
<tr>
<td>MUSIC 128</td>
<td>Stanford Laptop Orchestra: Composition, Coding, and Performance</td>
</tr>
<tr>
<td>MUSIC 250A</td>
<td>Physical Interaction Design for Music</td>
</tr>
<tr>
<td>MUSIC 256A</td>
<td>Music, Computing, Design: The Art of Design</td>
</tr>
</tbody>
</table>

**Advanced Research Topics/Electives**

3-5

Select one of the following:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS 108</td>
<td>Object-Oriented Systems Design</td>
</tr>
<tr>
<td>LINGUIST 105</td>
<td>Phonetics</td>
</tr>
<tr>
<td>LINGUIST 110</td>
<td>Introduction to Phonology</td>
</tr>
<tr>
<td>MUSIC 220C</td>
<td>Research Seminar in Computer-Generated Music</td>
</tr>
<tr>
<td>MUSIC 222</td>
<td>Sound in Space</td>
</tr>
<tr>
<td>MUSIC 253</td>
<td>Symbolic Musical Information</td>
</tr>
<tr>
<td>MUSIC 254</td>
<td>Computational Music Analysis</td>
</tr>
<tr>
<td>MUSIC 256B</td>
<td>Music, Computing, Design II: Virtual and Augmented Reality for Music</td>
</tr>
<tr>
<td>MUSIC 257</td>
<td>Neuroplasticity and Musical Gaming</td>
</tr>
</tbody>
</table>

**Total Units**

15-23

### Decision Making and Rationality

See also the Symbolic Systems website (https://symsys.stanford.edu/undergraduatesconcentrations/decision-making-and-rationality-dmr-concentration/).

Select five courses, including at least one course from each of the first four areas:

**Philosophical Inquiry**

Select one of the following:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>MS&amp;E 234</td>
<td>Data Privacy and Ethics</td>
</tr>
<tr>
<td>MS&amp;E 254</td>
<td>The Ethical Analyst</td>
</tr>
<tr>
<td>PHIL 164</td>
<td>Central Topics in the Philosophy of Science: Theory and Evidence</td>
</tr>
<tr>
<td>PHIL 166</td>
<td>Probability. Ten Great Ideas About Chance</td>
</tr>
<tr>
<td>PHIL 169</td>
<td>Evolution of the Social Contract</td>
</tr>
<tr>
<td>PHIL 170</td>
<td>Ethical Theory</td>
</tr>
<tr>
<td>PHIL 171</td>
<td>Justice</td>
</tr>
<tr>
<td>PHIL 172</td>
<td>History of Modern Moral Philosophy</td>
</tr>
<tr>
<td>PHIL 184</td>
<td>Topics in Epistemology</td>
</tr>
<tr>
<td>PHIL 187</td>
<td>Philosophy of Action</td>
</tr>
<tr>
<td>PHIL 194M</td>
<td>Capstone Seminar: Consequences for Ethics</td>
</tr>
<tr>
<td>PHIL 359</td>
<td>Topics in Logic, Information and Agency</td>
</tr>
<tr>
<td>PHIL 377</td>
<td>Social Agency</td>
</tr>
<tr>
<td>PHIL 386</td>
<td>Truth as the aim of belief and inquiry</td>
</tr>
<tr>
<td>PHIL 388</td>
<td>Topics in Normativity</td>
</tr>
<tr>
<td>POLISCI 131L</td>
<td>Modern Political Thought: Machiavelli to Marx and Mill</td>
</tr>
</tbody>
</table>

**Total Units**

15-25
POLISCI 230A  Classical Seminar: Origins of Political Thought

PSYCH 160  Seminar on Emotion

Note: PHIL 359 counts only if taken for 3 or more units, in accordance with the policy for all core courses.

Formal Decision Theories
Select one of the following:
ECON 51  Economic Analysis II
ECON 136  Market Design
ECON 160  Game Theory and Economic Applications
ECON 180  Honors Game Theory
ECON 289  Advanced Topics in Game Theory and Information Economics
INTLPOL 204A  Microeconomics for Policy
MGTCON 613  Foundations of Game Theory
MGTCON 616  Topics in Microeconomic Theory
MS&E 232  Introduction to Game Theory
PHIL 154  Modal Logic
PHIL 351  Representation Theorems
PHIL 351C  Formal Methods in Ethics
PHIL 351D  Measurement Theory
PHIL 359  Topics in Logic, Information and Agency
POLISCI 356A  Formal Theory I: Game Theory for Political Science

PUBLPOL 51  Microeconomics for Policy

Note: PHIL 359 counts only if taken for 3 or more units, in accordance with the policy for all core courses.

Empirical Findings and Explanations
Select one of the following:
BIO 150  Human Behavioral Biology
COMM 172  Media Psychology
ECON 178  Behavioral Economics
ECON 179  Experimental Economics
ECON 279  Behavioral and Experimental Economics II
GSBGEN 646  Behavioral Economics and the Psychology of Decision Making
MS&E 389  Seminar on Organizational Theory
POLISCI 351B  Economic Analysis of Political Institutions
POLISCI 351C  Institutions and Bridge-Building in Political Economy
PSYCH 45  Introduction to Learning and Memory
PSYCH 50  Introduction to Cognitive Neuroscience
PSYCH 70  Self and Society: Introduction to Social Psychology
PSYCH 75  Introduction to Cultural Psychology
PSYCH 80  Introduction to Personality and Affective Science
PSYCH 154  Judgment and Decision-Making
PSYCH 160  Seminar on Emotion
PSYCH 205  Foundations of Cognition
PSYCH 212  Classic and contemporary social psychology research
PSYCH 215  Mind, Culture, and Society
PSYCH 223  Social Norms
PSYCH 232  Brain and Decision
PSYCH 251  Experimental Methods
PSYCH 270  The Self: Representations and Interventions

SOC 114  Economic Sociology
SOC 115  Topics in Economic Sociology
SOC 120  Interpersonal Relations
SOC 126  Introduction to Social Psychology
SYMSYS 203  Cognitive Science Perspectives on Humanity and Well-Being
SYMSYS 275  Collective Behavior and Distributed Intelligence

Practical Tools and Applications
Select one of the following:
CEE 206  Decision Analysis for Civil and Environmental Engineers
CS 181  Computers, Ethics, and Public Policy
CS 182  Ethics, Public Policy, and Technological Change
CS 228  Probabilistic Graphical Models: Principles and Techniques
CS 238  Decision Making under Uncertainty
CS 239  Advanced Topics in Sequential Decision Making
CS 325B  Data for Sustainable Development
ECON 135  Foundations of Finance
ECON 136  Market Design
ECON 137  Decision Modeling and Information
ECON 141  Public Finance and Fiscal Policy
ECON 150  Economic Policy Analysis
ECON 155  Environmental Economics and Policy
ECON 162  Games Developing Nations Play
ECON 247  Labor Economics II
MS&E 152  Introduction to Decision Analysis
MS&E 180  Organizations: Theory and Management
MS&E 250A  Engineering Risk Analysis
MS&E 250B  Project Course in Engineering Risk Analysis
MS&E 251  Introduction to Stochastic Control with Applications
MS&E 252  Decision Analysis I: Foundations of Decision Analysis
MS&E 352  Decision Analysis II: Professional Decision Analysis
MS&E 353  Decision Analysis III: Frontiers of Decision Analysis
MS&E 355  Influence Diagrams and Probabilistic Networks
POLISCI 152  Introduction to Game Theoretic Methods in Political Science
POLISCI 153  Thinking Strategically
SYMSYS 201  Digital Technology, Society, and Democracy
SYMSYS 271  Group Democracy
SYMSYS 275  Collective Behavior and Distributed Intelligence
URBANST 132  Concepts and Analytic Skills for the Social Sector

Methodological Foundations
BIOMEDIN 251  Outcomes Analysis
COMM 106  Communication Research Methods
CS 147  Introduction to Human-Computer Interaction Design
CS 154  Introduction to the Theory of Computation
CS 161  Design and Analysis of Algorithms
Human-Computer Interaction
See also the Symbolic Systems website (https://symsys.stanford.edu/undergraduatesconcentrations/human-computer-interaction-hci-concentration/).

### HCI Introduction

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS 147</td>
<td>Introduction to Human-Computer Interaction Design</td>
</tr>
</tbody>
</table>

**Units:** 3-5

### HCI-Project-Based Courses

Select one of the following:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS 194H</td>
<td>User Interface Design Project</td>
</tr>
<tr>
<td>CS 247A</td>
<td>Design for Artificial Intelligence</td>
</tr>
<tr>
<td>CS 247B</td>
<td>Design for Behavior Change</td>
</tr>
<tr>
<td>CS 247G</td>
<td>Introduction to Game Design</td>
</tr>
<tr>
<td>CS 247I</td>
<td>Design for Understanding</td>
</tr>
<tr>
<td>CS 247S</td>
<td>Service Design</td>
</tr>
<tr>
<td>CS 278</td>
<td>Social Computing</td>
</tr>
<tr>
<td>CS 347</td>
<td>Human-Computer Interaction: Foundations and Frontiers</td>
</tr>
<tr>
<td>CS 377E</td>
<td>Designing Solutions to Global Grand Challenges</td>
</tr>
<tr>
<td>CS 377G</td>
<td>Designing Serious Games</td>
</tr>
<tr>
<td>CS 377Q</td>
<td>Designing for Accessibility</td>
</tr>
<tr>
<td>CS 377U</td>
<td>Understanding Users</td>
</tr>
<tr>
<td>CS 448B</td>
<td>Data Visualization</td>
</tr>
<tr>
<td>EDUC 230</td>
<td>Learning Experience Design</td>
</tr>
<tr>
<td>EDUC 302</td>
<td>Behavior Design</td>
</tr>
<tr>
<td>EDUC 303</td>
<td>Designing Learning Spaces</td>
</tr>
<tr>
<td>EDUC 391</td>
<td>Engineering Education and Online Learning Perspectives in Assistive Technology (ENGR 110)</td>
</tr>
<tr>
<td>ENGR 110</td>
<td></td>
</tr>
<tr>
<td>MED 275B</td>
<td>Biodesign Fundamentals</td>
</tr>
</tbody>
</table>

**Total Units:** 15-25

### HCI Social and Psychological Aspects

Select one of the following:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>COMM 1</td>
<td>Introduction to Communication</td>
</tr>
<tr>
<td>COMM 1B</td>
<td>Media, Culture, and Society</td>
</tr>
<tr>
<td>COMM 120W</td>
<td>The Rise of Digital Culture</td>
</tr>
<tr>
<td>COMM 145</td>
<td>Personality and Digital Media</td>
</tr>
<tr>
<td>COMM 166</td>
<td>Virtual People</td>
</tr>
<tr>
<td>COMM 172</td>
<td>Media Psychology</td>
</tr>
<tr>
<td>COMM 322</td>
<td>Advanced Studies in Behavior and Social Media</td>
</tr>
<tr>
<td>COMM 326</td>
<td>Advanced Topics in Human Virtual Representation</td>
</tr>
<tr>
<td>CS 80Q</td>
<td>Race and Gender in Silicon Valley</td>
</tr>
<tr>
<td>CS 181W</td>
<td>Computers, Ethics, and Public Policy</td>
</tr>
<tr>
<td>EDUC 281</td>
<td>Technology for Learners</td>
</tr>
<tr>
<td>EDUC 328</td>
<td>Topics in Learning and Technology: Core Mechanics for Learning</td>
</tr>
<tr>
<td>EDUC 342</td>
<td>Child Development and New Technologies</td>
</tr>
<tr>
<td>ME 115A</td>
<td>Introduction to Human Values in Design</td>
</tr>
<tr>
<td>MS&amp;E 135</td>
<td>Networks</td>
</tr>
<tr>
<td>MS&amp;E 234</td>
<td>Data Privacy and Ethics</td>
</tr>
<tr>
<td>PSYCH 70</td>
<td>Self and Society: Introduction to Social Psychology</td>
</tr>
<tr>
<td>STS 1</td>
<td>The Public Life of Science and Technology</td>
</tr>
<tr>
<td>SYMSYS 201</td>
<td>Digital Technology, Society, and Democracy</td>
</tr>
<tr>
<td>SYMSYS 245</td>
<td>Cognition in Interaction Design</td>
</tr>
<tr>
<td>SYMSYS 255</td>
<td>Building Digital History: Informatics of Social Movements and Protest</td>
</tr>
<tr>
<td>SYMSYS 275</td>
<td>Collective Behavior and Distributed Intelligence</td>
</tr>
</tbody>
</table>

**Units:** 3-5

### HCI Programming

Select one of the following:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS 108</td>
<td>Object-Oriented Systems Design</td>
</tr>
<tr>
<td>CS 142</td>
<td>Web Applications</td>
</tr>
<tr>
<td>CS 148</td>
<td>Introduction to Computer Graphics and Imaging</td>
</tr>
<tr>
<td>LINGUIST 180</td>
<td>From Languages to Information</td>
</tr>
</tbody>
</table>

**Units:** 3-4

### HCI Empirical Methods

Select one of the following:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>COMM 106</td>
<td>Communication Research Methods</td>
</tr>
<tr>
<td>CS 347</td>
<td>Human-Computer Interaction: Foundations and Frontiers</td>
</tr>
<tr>
<td>CS 377U</td>
<td>Understanding Users</td>
</tr>
<tr>
<td>EDUC 407</td>
<td>Lytics Seminar</td>
</tr>
<tr>
<td>EDUC 423</td>
<td>Introduction to Data Science</td>
</tr>
<tr>
<td>ENGR 150</td>
<td>Data Challenge Lab</td>
</tr>
<tr>
<td>HUMBIO 82A</td>
<td>Qualitative Research Methodology</td>
</tr>
<tr>
<td>ME 341</td>
<td>Design Experiments</td>
</tr>
<tr>
<td>MED 147</td>
<td>Methods in Community Assessment, Evaluation, and Research</td>
</tr>
<tr>
<td>MS&amp;E 125</td>
<td>Introduction to Applied Statistics</td>
</tr>
<tr>
<td>PSYCH 251</td>
<td>Experimental Methods</td>
</tr>
<tr>
<td>PSYCH 252</td>
<td>Statistical Methods for Behavioral and Social Sciences</td>
</tr>
<tr>
<td>STATS 101</td>
<td>Data Science 101</td>
</tr>
<tr>
<td>STATS 191</td>
<td>Introduction to Applied Statistics</td>
</tr>
</tbody>
</table>

**Units:** 3-5
### Symbolic Systems

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>STATS 200</td>
<td>Introduction to Statistical Inference</td>
</tr>
<tr>
<td>STATS 202</td>
<td>Data Mining and Analysis</td>
</tr>
<tr>
<td>STATS 263</td>
<td>Design of Experiments</td>
</tr>
</tbody>
</table>

**Total Units** 15-23

### Learning

See also the Symbolic Systems website (https://symsys.stanford.edu/undergraduatesconcentrations/learning-concentration/).

**Units**

Select five courses from at least two of the following three areas: 15-25

#### Computational Learning
- **CS 205L** Continuous Mathematical Methods with an Emphasis on Machine Learning
- **CS 224N** Natural Language Processing with Deep Learning
- **CS 228** Probabilistic Graphical Models: Principles and Techniques
- **CS 229** Machine Learning
- **CS 234** Reinforcement Learning
- **CS 236** Deep Generative Models
- **CS 325B** Data for Sustainable Development
- **EE 104** Introduction to Machine Learning
- **EE 276** Information Theory
- **MS&E 234** Data Privacy and Ethics
- **PSYCH 204** Computation and Cognition: The Probabilistic Approach
- **STATS 101** Data Science 101
- **STATS 315A** Modern Applied Statistics: Learning
- **STATS 315B** Modern Applied Statistics: Data Mining

#### Human Learning
- **EDUC 101** Introduction to Teaching and Learning
- **EDUC 115N** How to Learn Mathematics
- **EDUC 218** Topics in Cognition and Learning: Technology and Multitasking
- **EDUC 266** Educational Neuroscience
- **EDUC 368** Cognitive Development in Childhood and Adolescence
- **LINGUIST 140** Learning to Speak: An Introduction to Child Language Acquisition
- **LINGUIST 248** Seminar in Developmental Psycholinguistics
- **PSYCH 45** Introduction to Learning and Memory
- **PSYCH 50** Introduction to Cognitive Neuroscience
- **PSYCH 60** Introduction to Developmental Psychology
- **PSYCH 141** Cognitive Development
- **PSYCH 145** Seminar on Infant Development
- **PSYCH 169** Advanced Seminar on Memory
- **PSYCH 202** Cognitive Neuroscience
- **PSYCH 204** Computation and Cognition: The Probabilistic Approach
- **PSYCH 251** Experimental Methods
- **PSYCH 265** Social Psychology and Social Change
- **PSYCH 266** Current Debates in Learning and Memory

**Learning Environment Design**
- **COMM 322** Advanced Studies in Behavior and Social Media
- **CS 147** Introduction to Human-Computer Interaction Design
- **CS 194H** User Interface Design Project
- **EDUC 211** Beyond Bits and Atoms - Lab
- **EDUC 230** Learning Experience Design
- **EDUC 236** Beyond Bits and Atoms: Designing Technological Tools
- **EDUC 281** Technology for Learners
- **EDUC 298** Seminar on Teaching Introductory Computer Science
- **EDUC 303** Designing Learning Spaces
- **EDUC 328** Topics in Learning and Technology: Core Mechanics for Learning
- **EDUC 333A** Understanding Learning Environments
- **EDUC 342** Child Development and New Technologies
- **EDUC 391** Engineering Education and Online Learning
- **EDUC 426** Unleashing Personal Potential: Behavioral Science and Design Thinking Applied to Self
- **MUSIC 257** Neuroplasticity and Musical Gaming
- **SYMSYS 245** Cognition in Interaction Design
- **SYMSYS 255** Building Digital History: Informatics of Social Movements and Protest

**Total Units** 15-25

### Natural Language

See also the Symbolic Systems website (https://symsys.stanford.edu/undergraduatesconcentrations/natural-language-nl-concentration/).

**Units**

Select five courses from three or four of the following seven areas: 15-21

#### Mathematical/Computational Foundations
- **CS 154** Introduction to the Theory of Computation
- **CS 221** Artificial Intelligence: Principles and Techniques
- **CS 229** Machine Learning
- **PHIL 154** Modal Logic
- **PSYCH 204** Computation and Cognition: The Probabilistic Approach
- **PSYCH 209** Neural Network Models of Cognition
- **PSYCH 254** Affective Neuroscience

#### Computational Linguistics
- **CS 124** From Languages to Information
- **CS 224N** Natural Language Processing with Deep Learning
- **CS 224S** Spoken Language Processing
- **CS 224U** Natural Language Understanding
- **CS 276** Information Retrieval and Web Search
- **SYMSYS 112** Challenges for Language Systems

#### Phonetics/Phonology/Speech
- **LINGUIST 105** Phonetics
- **LINGUIST 110** Introduction to Phonology
- **LINGUIST 112** Seminar in Phonology: Stress, Tone, and Accent
- **LINGUIST 157** Sociophonetics
- **LINGUIST 205B** Advanced Phonetics
- **LINGUIST 207A** Advanced Phonetics
- **LINGUIST 210A** Phonology
- **LINGUIST 213** Corpus Phonology
- **LINGUIST 260A** Historical Morphology and Phonology
Morphosyntax
LINGUIST 121A The Syntax of English
LINGUIST 121B Crosslinguistic Syntax
LINGUIST 217 Morphosyntax
LINGUIST 222A Foundations of Syntactic Theory I
LINGUIST 225D Seminar in Syntax: Advanced Topics
LINGUIST 260B Historical Morphosyntax

Semantics/Pragmatics/Philosophy of Language
LINGUIST 130A Introduction to Semantics and Pragmatics
LINGUIST 130B Introduction to Lexical Semantics
LINGUIST 132 Lexical Semantic Typology
LINGUIST 230B Advanced Semantics
LINGUIST 232A Lexical Semantics
LINGUIST 236 Seminar in Semantics: Causation
PHIL 137 Wittgenstein
PHIL 181 Philosophy of Language
PHIL 182 Advanced Philosophy of Language
PHIL 182A Naturalizing Representation
PHIL 194D Capstone Seminar: Artificial Intelligence
PHIL 194K Slurs and Derogation: Semantic, Pragmatic and Ethical Perspectives
PHIL 348 Evolution of Signalling
PHIL 385D Advanced Topics in Philosophy of Language
SYMSYS 112 Challenges for Language Systems

Psycholinguistics
LINGUIST 140 Learning to Speak: An Introduction to Child Language Acquisition
LINGUIST 246 Foundations of Psycholinguistics
LINGUIST 248 Seminar in Developmental Psycholinguistics
PSYCH 132 Language and Thought
PSYCH 140 Introduction to Psycholinguistics
PSYCH 209 Neural Network Models of Cognition

Sociolinguistics and Language Change
LINGUIST 65 African American Vernacular English
LINGUIST 150 Language and Society
LINGUIST 152 Sociolinguistics and Pidgin Creole Studies
LINGUIST 156 Language, Gender, & Sexuality
LINGUIST 157 Sociophonetics
LINGUIST 159 American Dialects

Total Units 15-21

Neurosciences
See also the Symbolic Systems website (https://symsys.stanford.edu/undergraduatesconcentrations/neurosciences-neuro-concentration/).

Basic Neuroscience
Select at least one course from the following:
BIO 84 Physiology
BIO 150 Human Behavioral Biology
BIO 151 Mechanisms of Neuron Death
BIO 153 Cellular Neuroscience: Cell Signaling and Behavior
BIO 154 Molecular and Cellular Neurobiology
HUMBIO 4A The Human Organism
NBIO 206 The Nervous System
NBIO 258 Information and Signaling Mechanisms in Neurons and Circuits
PSYCH 121 Ion Transport and Intracellular Messengers
Note: NBIO 206 is a 6-unit course, which counts as two concentration courses, from areas 1 and 2.

Systems Neuroscience
Select at least one course from the following:
BIO 158 Developmental Neurobiology
BIO 222 Exploring Neural Circuits
EDUC 266 Educational Neuroscience
PSYC 124 Brain Plasticity
PSYCH 45 Introduction to Learning and Memory
PSYCH 50 Introduction to Cognitive Neuroscience
PSYCH 162 Brain Networks
PSYCH 169 Advanced Seminar on Memory
PSYCH 232 Brain and Decision
PSYCH 254 Affective Neuroscience
PSYCH 266 Current Debates in Learning and Memory

Computational Approaches
BIOE 101 Systems Biology
CS 223A Introduction to Robotics
CS 229 Machine Learning
CS 379C Computational Models of the Neocortex
EE 124 Introduction to Neuroelectrical Engineering
MUSIC 257 Neuroplasticity and Musical Gaming
PSYCH 164 Brain decoding
PSYCH 204A Human Neuroimaging Methods
PSYCH 204B Computational Neuroimaging
PSYCH 209 Neural Network Models of Cognition
PSYCH 249 Large-Scale Neural Network Modeling for Neuroscience
PSYCH 287 Brain Machine Interfaces: Science, Technology, and Application

Biological and Computational Approaches to Vision
CS 131 Computer Vision: Foundations and Applications
CS 231A Computer Vision: From 3D Reconstruction to Recognition
CS 231N Convolutional Neural Networks for Visual Recognition
PSYCH 30 Introduction to Perception
PSYCH 221 Image Systems Engineering
PSYCH 250 High-level Vision: From Neurons to Deep Neural Networks

Methodological Foundations
APPPHYS 293 Theoretical Neuroscience
NBIO 101 Social and Ethical Issues in the Neurosciences
PHIL 167D Philosophy of Neuroscience
PHIL 186 Philosophy of Mind
PHIL 360 Grad Seminar: Philosophy of Neuroscience
SYMSYS 202 Theories of Consciousness
SYMSYS 207 Conceptual Issues in Cognitive Science

Methodological Foundations

Units

Stanford Bulletin 2019-20
### Symbolic Systems

- **BIOE 291** Principles and Practice of Optogenetics for Optical Control of Biological Tissues
- **CS 205L** Continuous Mathematical Methods with an Emphasis on Machine Learning
- **EE 102A** Signal Processing and Linear Systems I
- **EE 102B** Signal Processing and Linear Systems II
- **EE 261** The Fourier Transform and Its Applications
- **EE 263** Introduction to Linear Dynamical Systems
- **MATH 113** Linear Algebra and Matrix Theory
- **MS&E 211** Introduction to Optimization
- **PSYCH 204A** Human Neuroimaging Methods
- **PSYCH 252** Statistical Methods for Behavioral and Social Sciences
- **PSYCH 253** Advanced Statistical Modeling
- **STATS 141** Biostatistics
- **STATS 191** Introduction to Applied Statistics
- **STATS 200** Introduction to Statistical Inference

**Total Units**: 15-25

### Philosophical Foundations

See also the Symbolic Systems website ([https://symsys.stanford.edu/undergraduatesconcentrations/philosophical-foundations-concentration/](https://symsys.stanford.edu/undergraduatesconcentrations/philosophical-foundations-concentration/)).

#### Area 1

Select two of the following:

- **PHIL 180** Metaphysics
- **PHIL 181** Philosophy of Language
- **PHIL 182** Advanced Philosophy of Language
- **PHIL 182A** Naturalizing Representation
- **PHIL 183** Self-knowledge and Metacognition
- **PHIL 184** Topics in Epistemology
- **PHIL 185** Special Topics in Epistemology: Testimony in science and everyday life
- **PHIL 185W** Metaontology
- **PHIL 186** Philosophy of Mind
- **PHIL 186A** Self-fashioning
- **PHIL 187** Philosophy of Action
- **PHIL 188W** Paradoxes
- **PHIL 189G** Fine-Tuning Arguments for God's Existence

**Units**: 7-8

#### Area 2

Select one of the following:

- **PHIL 102** Modern Philosophy, Descartes to Kant
- **PHIL 170** Ethical Theory
- **PHIL 170B** Metaphor
- **PHIL 171** Justice
- **PHIL 171P** 20th Century Political Theory: Liberalism and its Critics
- **PHIL 172** History of Modern Moral Philosophy
- **PHIL 172B** Recent Ethical Theory: Moral Obligation
- **PHIL 172C** The Ethics of Care
- **PHIL 173B** Metaethics
- **PHIL 173W** Aesthetics
- **PHIL 175** Philosophy of Law
- **PHIL 176** Political Philosophy: The Social Contract Tradition
- **PHIL 176A** Classical Seminar: Origins of Political Thought
- **PHIL 177C** Ethics of Climate Change
- **PHIL 178** Ethics in Society Honors Seminar

**Area 3**: 3-4

Select one of the following:

- **PHIL 152** Computability and Logic
- **PHIL 154** Modal Logic
- **PHIL 351C** Formal Methods in Ethics
- **PHIL 356C** Logic and Artificial Intelligence
- **PHIL 357** Research Seminar on Logic and Cognition
- **PHIL 359** Topics in Logic, Information and Agency

**Area 4**: 3-4

Select one of the following:

- **PHIL 20N** Philosophy of Artificial Intelligence
- **PHIL 153L** Computing Machines and Intelligence
- **PHIL 162** Philosophy of Mathematics
- **PHIL 164** Central Topics in the Philosophy of Science: Theory and Evidence
- **PHIL 165** Philosophy of Physics: Space and Time
- **PHIL 166** Probability: Ten Great Ideas About Chance
- **PHIL 167D** Philosophy of Neuroscience
- **PHIL 169** Evolution of the Social Contract
- **PHIL 194Y** Capstone seminar: Common Sense Philosophy
- **PHIL 360** Grad Seminar: Philosophy of Neuroscience
- **PHIL 385B** Topics in Metaphysics and Epistemology: Situations and Attitudes
- **PSYCH 160** Seminar on Emotion
- **SYMSYS 112** Challenges for Language Systems
- **SYMSYS 202** Theories of Consciousness
- **SYMSYS 207** Conceptual Issues in Cognitive Science
- **SYMSYS 208** Computer Machines and Intelligence

**Total Units**: 16-21

### Individually Designed Concentrations (IDCs)

Individually Designed Concentrations (IDCs) consist of five courses in a coherent subject area related to symbolic systems. This relationship may be established through inclusion in an IDC of two or more courses that connect the proposed concentration to the core, i.e. courses that (a) directly apply disciplines included in the core and (b) are related by topic or methodology to the other courses in the proposed concentration.

Course selection is to be made in consultation with the student’s adviser and is subject to approval by the adviser, the Associate Director, and the Director. For examples of IDCs completed by past SSP students, consult the list of alumni and apply the filter ‘Individually Designed Concentration’.

Approval of an IDC must take place no less than two full quarters before a student plans to graduate, e.g. prior to the first day of Winter Quarter of the senior year if a student intends to graduate in June of that year. Failure to obtain approval by the required date will necessitate either completing the requirements for one of the suggested concentrations, or delaying graduation to the end of the second full quarter following approval of an IDC.

To get a proposed IDC approved, send an email message to symsys-directors at lists.stanford.edu, cc’d to your prospective concentration adviser, stating that the adviser has approved your proposal, and giving a title, one-paragraph description, and course plan for your proposed concentration.
Additional Information

Undergraduate Research
The program encourages all SSP majors to gain experience in directed research by participating in faculty research projects or by pursuing independent study. In addition to the Symbolic Systems Honors Program (see below), the following avenues are offered.

Summer Internships: students work on SSP-related faculty research projects. Application procedures are announced in the Winter Quarter for SSP majors.

Research Assistantships: other opportunities to work on faculty research projects are typically announced to SSP majors as they arise during the academic year.

Independent Study: under faculty supervision. For course credit, students should enroll in SYMSYS 196 Independent Study.

Contact SSP for more information on any of these possibilities, or see the Symbolic Systems (http://symsys.stanford.edu) web site. In addition, see the Undergraduate Advising and Research (https://undergrad.stanford.edu/opportunities/research.html) web site for information on UAR grants and scholarships supporting student research projects at all levels.

Honors Program
Seniors in SSP may apply for admission to the Symbolic Systems honors program prior to the beginning of their final year of study. Students who are accepted into the honors program can graduate with honors by completing an honors thesis under the supervision of a faculty member. Course credit for the honors project may be obtained by registering for SYMSYS 190 Senior Honors Tutorial any quarter while a student is working on an honors project. SYMSYS 191 Senior Honors Seminar, is recommended for honors students during the senior year. Contact SSP or visit the program’s web site for more information on the honors program, including deadlines and policies.

return to top of page (p. 1)

Minor in Symbolic Systems
Students may minor in Symbolic Systems by completing either Option 1 or Option 2. For additional information see the Symbolic Systems minors web site (http://symsys.stanford.edu/viewing/htmldocument/13635/).

Degree Requirements

Option 1
One course in each of the following core areas (please note that several of these courses have prerequisites):

<table>
<thead>
<tr>
<th>Area</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Cognition</td>
<td>3-4</td>
</tr>
<tr>
<td>b. Logic and Computation</td>
<td>3-5</td>
</tr>
<tr>
<td>c. Computer Programming</td>
<td>3-5</td>
</tr>
</tbody>
</table>

Select one of the following:
- SYMSYS 1 Minds and Machines (formerly SYMSYS 100)
- PSYCH 45 Introduction to Learning and Memory
- PSYCH 50 Introduction to Cognitive Neuroscience
- PHIL 150 Mathematical Logic
- PHIL 151 Metalogic
- CS 103 Mathematical Foundations of Computing

Interdisciplinary Concentration
An interdisciplinary SSP concentration listed on the SSP web site. To qualify, the selection of courses used for the minor must be interdisciplinary; it must either include courses from at least three departments, or include more than one course from each of two departments.

<table>
<thead>
<tr>
<th>Course</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>SYMSYS 1 Minds and Machines</td>
<td>4-5</td>
</tr>
</tbody>
</table>

Total Units 13

Option 2

<table>
<thead>
<tr>
<th>Course</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>SYMSYS 1 Minds and Machines</td>
<td>4</td>
</tr>
</tbody>
</table>

Interdisciplinary Concentration
An interdisciplinary SSP concentration listed on the SSP web site. To qualify, the selection of courses used for the minor must be interdisciplinary; it must either include courses from at least three departments, or include more than one course from each of two departments.

<table>
<thead>
<tr>
<th>Course</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>SYMSYS 1 Minds and Machines</td>
<td>4</td>
</tr>
</tbody>
</table>

Total Units 19

Coterminal Master's Degrees in Symbolic Systems
The Symbolic Systems M.S. Program admits a handful of coterminal students each year. Coterminal students usually complete the program in one academic year.
Applications for Coterminal admission of active Stanford undergraduates are reviewed in the Winter and Spring Quarters. For more details, see the Coterm admissions information (https://symmsys.stanford.edu/cotermadmissions/) on the Symbolic Systems Program website. Admission to the program as a coterminal student is subject to the policies and deadlines described in the ‘Coterminal Bachelor’s and Master’s Degrees’ (https://exploredegrees.stanford.edu/cotermdegrees/) section of this bulletin. The GRE is not required for coterminal applicants to the Symbolic Systems M.S. program.

Many SSP majors also complete coterminal M.S. or M.A. degrees in affiliated departments. In addition to the Symbolic Systems M.S. program, the Department of Philosophy offers a Special Program in Symbolic Systems track for interdisciplinary graduate level work leading to the Master of Arts in Philosophy (http://www.stanford.edu/dept/registrar/bulletin/4567.htm).

University Coterminal Requirements
Coterminal master’s degree candidates are expected to complete all master’s degree requirements as described in this bulletin. University requirements for the coterminal master’s degree are described in the “Coterminal Master’s Program” (http://exploredegrees.stanford.edu/cotermdegrees/) section. University requirements for the master’s degree are described in the ‘Graduate Degrees’ (http://exploredegrees.stanford.edu/graduatedegrees/#masterstext) section of this bulletin.

After accepting admission to this coterminal master’s degree program, students may request transfer of courses from the undergraduate to the graduate career to satisfy requirements for the master’s degree. Transfer of courses to the graduate career requires review and approval of both the undergraduate and graduate programs on a case by case basis.

In this master’s program, courses taken during or after the first quarter of the sophomore year are eligible for consideration for transfer to the graduate career; the timing of the first graduate quarter is not a factor. No courses taken prior to the first quarter of the sophomore year may be used to meet master’s degree requirements.

Course transfers are not possible after the bachelor’s degree has been conferred.

The University requires that the graduate advisor be assigned in the student’s first graduate quarter even though the undergraduate career may still be open. The University also requires that the Master’s Degree Program Proposal be completed by the student and approved by the department by the end of the student’s first graduate quarter.

Master of Science in Symbolic Systems
The University’s basic requirements for the M.S. degree are discussed in the ‘Graduate Degrees’ (http://exploredegrees.stanford.edu/graduatedegrees/) section of this bulletin.

The M.S. degree in Symbolic Systems is designed to be completed in the equivalent of one academic year by coterminal students or returning students who already have a B.S. degree in Symbolic Systems, and in two years or less by other students depending upon level of preparation. Admission is competitive, providing a limited number of students with the opportunity to pursue course and project work in consultation with a faculty adviser who is affiliated with the Symbolic Systems Program. The faculty adviser may impose requirements beyond those described here.

Admission to the program as a coterminal student is subject to the policies and deadlines described in the ‘Coterminal Bachelor’s and Master’s Degrees’ (http://exploredegrees.stanford.edu/cotermdegrees/) section of this bulletin. Applicants to the M.S. program are reviewed each Winter Quarter. Information on deadlines, procedures for applying, and degree requirements are available from the program’s student services coordinator in the Linguistics Department office (460-127E) and at the Symbolic Systems (http://symmsys.stanford.edu/viewing/htmldocument/13623/) web site.

Note, the GRE is required for external applicants.

Symbolic Systems also offers a Joint Degree with Law School (M.S./J.D.).

Director of Graduate Studies: Hyowon Gweon

Degree Requirements
A candidate for the M.S. degree in Symbolic Systems must complete a program of 45 units. All courses must be 100-level and above. At least 0 of these must be graded units, passed with an average grade of 3.0 (B) or better, and any course taken as part of the 45 unit program must be taken for a letter grade unless the course is offered S/NC only. None of the 45 units to be counted toward the M.S. degree may include units counted toward an undergraduate degree at Stanford or elsewhere. Course requirements for the M.S. degree in Symbolic Systems may be waived after a review by the program office. Waivers are granted at the discretion of the program, and only if evidence is provided that similar or more advanced courses have been taken and passed with a letter grade of B or its equivalent, either at Stanford or another institution, and as part of another degree program which the student has either completed or is pursuing in parallel with the Symbolic Systems M.S. degree. Course requirements that are waived rather than fulfilled by courses taken at Stanford may not be counted toward the 45 units required for the Symbolic Systems M.S. degree. For additional information, see the Symbolic Systems web site (http://symmsys.stanford.edu/graduate_programs/).

Each candidate for the M.S. degree must fulfill the following requirements:

1. Submission to the Symbolic Systems Program office and approval of the following pre-project research documents:
   a. Project Area Statement, endorsed with a commitment from a student’s prospective project adviser no later than May 1 of the academic year prior to the expected graduation year; and
   b. Qualifying Research Paper due no later than the end of the Summer Quarter prior to the expected graduation year.
2. Completion of a coherent plan of study, to be approved by the Program Director, Director of Graduate Studies, or Associate Director, in consultation with the student’s primary adviser (for students with an approved Project Area Statement), and designed to support a student’s project as well as the core course requirements for the M.S. degree (requirements 3 and 4 below). An initial plan of study should be delineated on the Program Proposal Form prior to the end of the student’s first quarter of study, as required by the University. The final version of the Program Proposal, which should specify all the courses which the student has taken and proposes in fulfillment of both the Program’s and the University’s course and unit requirements for the degree, is due by the end of Finals Week in the quarter prior to the student’s expected graduation quarter (i.e. end of Winter Quarter for a student graduating in the Spring).
3. Completion of the Master’s Breadth Requirements. The Program Proposal must include courses taken for 3 units or more each that are more advanced than the Symbolic Systems undergraduate core in four main skill areas: formal, empirical, computational, and philosophical; and in at least three of the following departments (based on the listing as any cross-listing departments): Computer Science, Linguistics, Philosophy, and Psychology. Courses to fulfill the Breadth Requirements must be taken for a letter grade if available.

Acceptable courses in each of the four required skill areas are defined as follows:
a) Formal: a course in logic and computational theory beyond the level of PHIL 151 Metalogic. The courses below have been approved. Other courses may be approved if appropriate.

- PHIL 252 Computability and Logic
- PHIL 254 Modal Logic
- PHIL 356C Logic and Artificial Intelligence
- PHIL 357 Research Seminar on Logic and Cognition
- CS 154 Introduction to the Theory of Computation
- CS 157 Computational Logic
- CS 161 Design and Analysis of Algorithms
- CS 261 Optimization and Algorithmic Paradigms

b) Empirical: a course drawing on experimental or observational data or methods, beyond the level of PSYCH 55, LINGUIST 120 or 130A. The courses below are examples of those that have been approved. Other courses may be approved if appropriate.

- CS 224N Natural Language Processing with Deep Learning
- CS 224U Natural Language Understanding
- CS 229 Machine Learning
- CS 376 Research Topics in Human-Computer Interaction
- LINGUIST 230B Advanced Semantics
- NBIIO 206 The Nervous System
- NBIIO 258 Information and Signaling Mechanisms in Neurons and Circuits
- PSYCH 204 Computation and Cognition: The Probabilistic Approach
- PSYCH 204A Human Neuroimaging Methods
- PSYCH 209 Neural Network Models of Cognition
- PSYCH 251 Experimental Methods
- PSYCH 252 Statistical Methods for Behavioral and Social Sciences
- STATS 200 Introduction to Statistical Inference
- SYMSYS 245 Cognition in Interaction Design

c) Computational: a course involving programming beyond the level of CS 107. The courses below have been approved. Other courses may be approved if appropriate.

- CS 108 Object-Oriented Systems Design
- CS 110 Principles of Computer Systems
- CS 124 From Languages to Information
- CS 142 Web Applications
- CS 143 Compilers
- CS 145 Data Management and Data Systems
- CS 148 Introduction to Computer Graphics and Imaging
- CS 210A Software Project Experience with Corporate Partners
- CS 221 Artificial Intelligence: Principles and Techniques
- CS 224N Natural Language Processing with Deep Learning
- CS 224W Machine Learning with Graphs
- CS 246 Mining Massive Data Sets

d) Philosophical: a course in the area of Philosophy of Mind/Language/Science/Epistemology or Metaphysics at the 200 level or above, certified by the instructor as worthy of graduate credit. The courses below are examples of those that have been approved. Other courses may be approved if appropriate.

- PHIL 264 Central Topics in the Philosophy of Science: Theory and Evidence
- PHIL 267D Philosophy of Neuroscience
- PHIL 281 Philosophy of Language
- PHIL 281C

- PHIL 283 Self-knowledge and Metacognition
- PHIL 286 Philosophy of Mind
- PHIL 286A Self-fashioning
- PHIL 287 Philosophy of Action
- PHIL 327 Scientific Philosophy: From Kant to Kuhn and Beyond
- PHIL 348 Evolution of Signalling
- PHIL 359 Topics in Logic, Information and Agency
- PHIL 377 Social Agency


5. Completion of a substantial project appropriate to the Program Proposal, represented by the M.S. Thesis. The project and thesis normally take three quarters or more to complete, and work on the project may account for up to 15 units of a student's 45-unit program. The thesis must be read and approved for the master's degree in Symbolic Systems by two qualified readers approved by the program, at least one of whom must be a member of the academic council. A hard copy of the thesis must be submitted to the Associate Director of Symbolic Systems, including the signatures of each reader indicating approval of the thesis for the degree of Master of Science, no later than 12 noon on the day of the University Dissertation/Thesis Submission Deadline (https://studentaffairs.stanford.edu/registrar/students/dissertation-thesis/) for the quarter of a student's graduation. A digital copy must be uploaded to the Stanford Digital Repository by the same deadline. For more details, see the Master's Thesis information (https://symsys.stanford.edu/graduatesmasters-program/masters-thesis/) on the Symbolic Systems Program website.

COVID-19 Policies

On July 30, the Academic Senate adopted grading policies effective for all undergraduate and graduate programs, excepting the professional Graduate School of Business, School of Law, and the School of Medicine M.D. Program. For a complete list of those and other academic policies relating to the pandemic, see the 'COVID-19 Policies' section of this bulletin.

The Senate decided that all undergraduate and graduate courses offered for a letter grade must also offer students the option of taking the course for a "credit" or "no credit" grade and recommended that deans, departments, and programs consider adopting local policies to count courses taken for a "credit" or "satisfactory" grade toward the fulfillment of degree-program requirements and/or alter program requirements as appropriate.

The Symbolic System Program is in the process of making decisions concerning COVID-19 policies and will update this tab when those decisions have been made.

Graduate Advising Expectations

The Symbolic Systems Program is committed to providing academic advising in support of graduate student scholarly and professional development. When most effective, this advising relationship entails collaborative and sustained engagement by both the adviser and the advisee. As a best practice, advising expectations should be periodically discussed and reviewed to ensure mutual understanding. Both the adviser and the advisee are expected to maintain professionalism and integrity.

Faculty advisers guide students in key areas such as selecting courses, designing and conducting research, developing of teaching pedagogy,
navigating policies and degree requirements, and exploring academic opportunities and professional pathways.

Graduate students are active contributors to the advising relationship, proactively seeking academic and professional guidance and taking responsibility for informing themselves of policies and degree requirements for their graduate program. Students are expected to meet regularly with their advisers and to keep them informed about their academic progress. Each student and their adviser should mutually agree on the frequency of these meetings when the advising relation begins and reassess their frequency at the start of every quarter.

For a statement of University policy on graduate advising, see the 'Graduate Advising [http://exploredegrees.stanford.edu/graduatedegrees/#advisingandcredentialstext]' section of this bulletin.

**Faculty**

*Director:* Michael C. Frank

*Director of Graduate Studies:* Hyowon Gweon

*Associate Director:* Todd Davies

*Faculty Advisory Board:* Jeremy Bailenson, Michael Bernstein, Ray Briggs, Todd Davies, Judith Degen, Michael C. Frank, Noah Goodman, Hyowon Gweon, Thomas Icard, Daniel Jurafsky, Daniel Lassiter, Krista Lawlor, Christopher Manning, James McClelland, Stanley Peters, Christopher Potts, Mehran Sahami, Johan van Benthem, Thomas A. Wasow

*Executive Committee:* Michael Bernstein, Todd Davies, Michael C. Frank, Hyowon Gweon, Thomas Icard, Christopher Potts

*Program Faculty:*

**Aeronautics and Astronautics:** Mykel Kochenderfer (Assistant Professor)

**Biology:** Deborah Gordon (Professor)

**Classics:** Reviel Netz (Professor)

**Communication:** Jeremy Bailenson (Professor), Jeff Hancock (Professor), Byron Reeves (Professor), Frederick Turner (Professor)

**Computer Science:** Maneesh Agrawala (Professor), Michael Bernstein (Assistant Professor), Emma Brunskill (Assistant Professor), David Dill (Professor, emeritus), Chelsea Finn (Assistant Professor), Michael Genesereth (Associate Professor), Oussama Khatib (Professor), Daphne Koller (Adjunct Professor), James Landay (Professor), Jean-Claude Latombe (Professor, emeritus), Marc Levoy (Professor, emeritus), Christopher Manning (Professor), Andrew Ng (Adjunct Professor), Chris Piech (Assistant Professor), Vaughan Pratt (Professor, emeritus), Eric Roberts (Professor, emeritus), Mehran Sahami (Professor, Teaching), Yoav Shoham (Professor, emeritus), Terry Winograd (Professor, emeritus)

**Economics:** Muriel Niederle (Professor)

**Education:** Nick Haber (Assistant Professor), Raymond P. McDermott (Professor, emeritus), Roy Pea (Professor), Daniel Schwartz (Professor)

**Electrical Engineering:** Chelsea Finn (Assistant Professor), Krishna Shenoy (Professor), Sebastian Thrun (Adjunct Professor)

**French and Italian:** Jean-PierreDupuy (Professor)

**Genetics:** Russ B. Altman (Professor)

**Graduate School of Business:** Baba Shiv (Professor)

**History:** Jessica G. Riskin (Professor)

**Law:** Mark Lemley (Professor)

**Linguistics:** Arto Antilla (Associate Professor), Joan Bresnan (Professor, emerita), Eve Clark (Professor, emerita), Cleo Condoravdi (Professor Research), Judith Degen (Assistant Professor), Penelope Eckert (Professor), Vera Gribovna (Associate Professor), Boris Harizanov (Assistant Professor), Daniel Jurafsky (Professor), Ronald Kaplan (Adjunct Professor), Lauri Karttunen (Adjunct Professor), Martin Kay (Professor), Paul Kiparsky (Professor), Daniel Lassiter (Assistant Professor), Beth Levin (Professor), Christopher Manning (Professor), Stanley Peters (Professor, emeritus), Christopher Potts (Professor), Meghan Sumner (Associate Professor), Thomas A. Wasow (Professor, emeritus), Annie Zaenen (Adjunct Professor)

**Management Science and Engineering:** Sharad Goel (Assistant Professor), Pamela Hinds (Professor), John Ugander (Assistant Professor)

**Mathematics:** Persi Diaconis (Professor)

**Mechanical Engineering:** Sean Follmer (Assistant Professor)

**Medicine:** Russ B. Altman (Professor), Mark Musen (Professor)

**Music:** Jonathan Berger (Professor), Christopher Chafe (Professor), Eleanor Selfridge-Field (Adjunct Professor), Ge Wang (Associate Professor)

**Neurobiology:** William T. Newsome (Professor), Jennifer Raymond (Professor)

**Philosophy:** Michael Bratman (Professor), Ray Briggs (Professor), Rosa Cao (Assistant Professor), Mark Crimmins (Associate Professor), John Etchemendi (Professor), Dagfinn Falbeson (Professor, emeritus), Thomas Icard III (Assistant Professor), Krista Lawlor (Professor), Anna-Sara Malmgren (Assistant Professor), John Perry (Professor, emeritus), Brian Skyrms (Professor), Johan van Benthem (Professor), Thomas A. Wasow (Professor, emeritus)

**Psychiatry and Behavioral Sciences:** Vinod Menon (Professor)

**Psychology:** Herbert H. Clark (Professor, emeritus), Anne Fernald (Associate Professor), Michael C. Frank (Associate Professor), Justin Gardner (Assistant Professor), Noah Goodman (Associate Professor), Kalanit Grill-Spector (Professor), Hyowon Gweon (Assistant Professor), Brian Knutson (Professor), Ellen Markman (Professor), James McClelland (Professor), Sean Malmgren (Assistant Professor), John Perry (Professor, emeritus), Brian Skyrms (Professor), Johan van Benthem (Professor), Thomas A. Wasow (Professor, emeritus)

**Statistics:** Persi Diaconis (Professor), Susan P. Holmes (Professor)

**Symbolic Systems:** Todd Davies (Associate Director), Jeff Shrager (Adjunct Professor), Paul Skokowski (Adjunct Professor)

**Other Affiliates:** David Barker-Plummer (CSLI Engineering Research Associate), Keith Devlin H-STAR Operation Senior Researcher), Daniel Flickinger (CSLI Research and Development Engineer), Cheryl Phillips (Lecturer in Communications)
Courses
SYMSYS 1. Minds and Machines. 4 Units.
(Formerly SYMSYS 100). An overview of the interdisciplinary study of cognition, information, communication, and language, with an emphasis on foundational issues: What are minds? What is computation? What are rationality and intelligence? Can we predict human behavior? Can computers be truly intelligent? How do people and technology interact, and how might they do so in the future? Lectures focus on how the methods of philosophy, mathematics, empirical research, and computational modeling are used to study minds and machines. Students must take this course before being approved to declare Symbolic Systems as a major. All students interested in studying Symbolic Systems are urged to take this course early in their student careers. The course material and presentation will be at an introductory level, without prerequisites.
Same as: CS 24, LINGUIST 35, PHIL 99, PSYCH 35, SYMSYS 200

SYMSYS 1P. A Practical Introduction to Symbolic Systems. 2 Units.
An optional supplement to 'Minds and Machines' (SYMSYS 1), aimed at prospective majors in Symbolic Systems. Students will learn from the perspectives of faculty, alums, and advanced students about how to navigate the many paths available to a student: Sym Sys versus other majors, undergraduate core options, selecting courses and a concentration, research opportunities, internships, the honors program, graduate programs, careers, and life paths.

SYMSYS 25. Introduction to Cognitive Science. 3 Units.
Cognitive Science explores one of sciences final frontiers; the scientific study of the human mind. It is a broad interdisciplinary field that encompasses research from areas in neuroscience, psychology, philosophy, linguistics, and computer science and covers topics such as the nature of knowledge, thinking, remembering, vision, imagery, language, and consciousness. All of which we will touch upon in this course and is intended to give students a sampler of each discipline. This introductory class will expose students to some of the major methodologies, experimental design, neuroscientific fundamentals, and different cognitive disorders. More importantly, it will help students refine their interest to a specific field within cognitive science for future studies at their respective institutions. This 6-week summer course will require a sizable amount of required reading, not all of the readings is covered in the lectures. To extend and complement topics in this field, there is material presented in the lectures that is not in the readings.

SYMSYS 20Q. The Data-Driven World. 3 Units.
Recent technological advancements have enabled us to measure, record, and analyze more data than ever before. How can we effectively use this data to solve real-world problems and better understand the world around us? In this course, we will learn how computers can create a statistical model to learn from human-generated data and find patterns or make predictions. We will explore different algorithms that create a statistical model to learn from human-generated data and find patterns or make predictions. We will discuss important ethical debates on the possible uses of data and their implications in today’s world. By the end of the course, students will develop a technical coding skillset to investigate hypotheses in any given dataset, and be able to connect the insights they derive to larger issues of society, equity, and justice.

SYMSYS 112. Challenges for Language Systems. 3-4 Units.
Parallel exploration of philosophical and computational approaches to modeling the construction of linguistic meaning. In philosophy of language: lexical sense extension, figurative speech, the semantics/pragmatics interface, contextualism debates. In CS: natural language understanding, from formal compositional models of knowledge representation to statistical and deep learning approaches. We will develop an appreciation of the complexities of language understanding and communication; this will inform discussion of the broader prospects for Artificial Intelligence. Special attention will be paid to epistemological questions on the nature of linguistic explanation, and the relationship between theory and practice. PREREQUISITES: PHIL80; some exposure to philosophy of language and/or computational language processing is recommended.
Same as: SYMSYS 212

SYMSYS 115. Critique of Technology. 3-4 Units.
What is the character of technology? How does technology reveal aspects of human nature and social practices? How does it shape human experience and values? We will survey the history of philosophy of technology – from ancient and enlightenment ideas, to positivist and phenomenological conceptions – to develop a deeper understanding of diverse technological worldviews. This will prepare us to consider contemporary questions about the ‘ethos’ of technology. Specific questions will vary depending upon the interests of participants, but may include: ethical and existential challenges posed by artificial intelligence; responsible product design in the ‘attention economy’; industry regulation and policy issues for information privacy; and the like. PREREQUISITES: PHIL80.

SYMSYS 122. Artificial Intelligence: Philosophy, Ethics, & Impact. 3-4 Units.
Recent advances in computing may place us at the threshold of a unique turning point in human history. Soon we are likely to entrust management of our environment, economy, security, infrastructure, food production, healthcare, and to a large degree even our personal activities, to artificially intelligent computer systems. The prospect of ‘turning over the keys’ to increasingly autonomous systems raises many complex and troubling questions. How will society respond as versatile robots and machine-learning systems displace an ever-expanding spectrum of blue- and white-collar workers? Will the benefits of this technological revolution be broadly distributed or accrue to a lucky few? How can we ensure that these systems respect our ethical principles when they make decisions at speeds and for rationales that exceed our ability to comprehend? What, if any, legal rights and responsibilities should we grant them? And should we regard them merely as sophisticated tools or as a newly emerging form of life? The goal of this course is to equip students with the intellectual tools, ethical foundation, and psychological framework to successfully navigate the coming age of intelligent machines.

SYMSYS 167D. Philosophy of Neuroscience. 4 Units.
How can we explain the mind? With approaches ranging from computational models to cellular-level characterizations of neural responses to the characterization of behavior, neuroscience aims to explain how we see, think, decide, and even feel. While these approaches have been highly successful in answering some kinds of questions, they have resulted in surprisingly little progress in others. We’ll look at the relationships between the neuroscientific enterprise, philosophical investigations of the nature of the mind, and our everyday experiences as creatures with minds. Prerequisite: PHIL 80. (Not open to freshmen.)
Same as: PHIL 167D, PHIL 267D

SYMSYS 190. Senior Honors Tutorial. 1-5 Units.
Under the supervision of their faculty honors adviser, students work on their senior honors project. May be repeated for credit.

SYMSYS 191. Senior Honors Seminar. 1 Unit.
Recommended for seniors doing an honors project. Under the leadership of the Symbolic Systems program coordinator, students discuss, and present their honors project.
SYMSYS 192. Symbolic Systems in Practice. 3 Units.
A professionalization course that fulfills the Practicum requirement of the Symbolic Systems undergraduate major Capstone. Online lectures, readings, assigned exercises, and live discussions relate the Sym Sys curriculum to a substantial work experience. Must be accompanied by an approved internship totaling 64 hours or more of total work time, which must be completed in the quarter prior to, during, or immediately following the course.

SYMSYS 195A. Design for Artificial Intelligence. 3-4 Units.
A project-based course that builds on the introduction to design in CS147 by focusing on advanced methods and tools for research, prototyping, and user interface design. Studio based format with intensive coaching and iteration to prepare students for tackling real world design problems. This course takes place entirely in studios; you must plan on attending every studio to take this class. The focus of CS247A is design for human-centered artificial intelligence experiences. What does it mean to design for AI? What is AI? How do you create responsible, ethical, human centered experiences? Let us explore what AI actually is and the constraints, opportunities and specialized processes necessary to create AI systems that work effectively for the humans involved. Prerequisites: CS147 or equivalent background in design thinking.

Same as: CS 247A

SYMSYS 195B. Design for Behavior Change. 3-4 Units.
Over the last decade, tech companies have invested in shaping user behavior, sometimes for altruistic reasons like helping people change bad habits into good ones, and sometimes for financial reasons such as increasing engagement. In this project-based hands-on course, students explore the design of systems, information and interface for human use. We will model the flow of interactions, data and context, and crafting a design that is useful, appropriate and robust. Students will design and prototype utility apps or games as a response to the challenges presented. We will also examine the ethical consequences of design decisions and explore current issues arising from unintended consequences. Prerequisite: CS147 or equivalent.

Same as: CS 247B

SYMSYS 195D. Research in Digital Democracy. 3-4 Units.
Digital democracy refers to social activity that is organized democratically at a group, institutional, or societal level, and that takes place within or is augmented by digital technology. This is a project-based research seminar designed to teach students methods for studying digital democracy, as well as collaborating in a group, the organization of a research project, and academic writing. The first few weeks of the course will be an overview of digital democracy research and its methods, as well as a time for students to organize into a group research project. The remainder of the class (about 7 weeks) will be spent performing and writing up the research for a targeted publication venue. Application required for enrollment. Prerequisite: At least one course in empirical methods or statistics. Prerequisites: At least one course in empirical methods or statistics.

Same as: SYMSYS 295D

SYMSYS 195E. Experimental Methods. 3 Units.
Graduate laboratory class in experimental methods for psychology, with a focus on open science methods and best practices in behavioral research. Topics include experimental design, data collection, data management, data analysis, and the ethical conduct of research. The final project of the course is a replication experiment in which students collect new data following the procedures of a published paper. The course is designed for incoming graduate students in psychology, but is open to qualified students from other programs who have some working knowledge of the R statistical programming language. Requirement: Psych 10/Stats 60 or equivalent.

Same as: PSYCH 251

SYMSYS 195G. Introduction to Game Design. 3-4 Units.
A project-based course that builds on the introduction to design in CS147 by focusing on advanced methods and tools for research, prototyping, and user interface design. Studio based format with intensive coaching and iteration to prepare students for tackling real world design problems. This course takes place entirely in studios; please plan on attending every studio to take this class. The focus of CS247G is an introduction to theory and practice of the design of games. We will make digital and paper games, do rapid iteration and run user research studies appropriate to game design. This class has multiple short projects, allowing us to cover a variety of genres, from narrative to pure strategy. Prerequisites: 147 or equivalent background.

Same as: CS 247G

SYMSYS 195I. Image Systems Engineering. 1-3 Unit.
This course is an introduction to digital imaging technologies. We focus on the principles of key elements of digital systems components; we show how to use simulation to predict how these components will work together in a complete image system simulation. The early lectures introduce the software environment and describe options for the course project. The following topics are covered and software tools are introduced:n- Basic principles of optics (Snell’s Law, diffraction, adaptive optics)n- Image sensor and pixel designn- Color science, metrics, and calibrationn- Human spatial resolutionn- Image processing principlesn- Display technologienA special theme of this course is that it explains how imaging technologies accommodate the requirements of the human visual system. The course also explains how image systems simulations can be useful in neuroscience and industrial vision applications.nThe course consists of lectures, software tutorials, and a course project. Tutorials and projects include extensive software simulations of the imaging pipeline. Some background in mathematics (linear algebra) and programming (Matlab) is valuable. Pre-requisite: EE 261 or equivalent. Or permission of instructor required.

Same as: PSYCH 221

SYMSYS 195L. Methods in Psycholinguistics. 4 Units.
Over the past ten years, linguists have become increasingly interested in testing theories with a wider range of empirical data than the traditionally accepted introspective judgments of hand-selected linguistic examples. Consequently, linguistics has seen a surge of interest in psycholinguistic methods across all subfields. This course will provide an overview of various standard psycholinguistic techniques and measures, including offline judgments (e.g., binary categorization tasks like truth-value judgments, Likert scale ratings, continuous slider ratings), response times, reading times, eye-tracking, ERPs, and corpus methods. Students will present and discuss research articles. Students will also run an experiment (either a replication or an original design, if conducive to the student’s research) to gain hands-on experience with experimental design and implementation in html/javascript and Mechanical Turk; data management, analysis, and visualization in R; and open science tools like git/github.

Same as: LINGUIST 245B

SYMSYS 195N. Natural Language Processing with Deep Learning. 3-4 Units.
Methods for processing human language information and the underlying computational properties of natural languages. Focus on deep learning approaches: understanding, implementing, training, debugging, visualizing, and extending neural network models for a variety of language understanding tasks. Exploration of natural language tasks ranging from simple word level and syntactic processing to coreference, question answering, and machine translation. Examination of representative papers and systems and completion of a final project applying a complex neural network model to a large-scale NLP problem. Prerequisites: calculus and linear algebra; CS124, CS221, or CS229.

Same as: CS 224N, LINGUIST 284
SYMSYS 195S. Service Design. 3-4 Units.
A project-based course that builds on the introduction to design in CS147 by focusing on advanced methods and tools for research, prototyping, and user interface design. Studio based format with intensive coaching and iteration to prepare students for tackling real-world design problems. This course takes place entirely in studios; you must plan on attending every studio to take this class. The focus of CS247S is Service Design. In this course we will be looking at experiences that address the needs of multiple types of stakeholders at different touchpoints - digital, physical, and everything in between. If you have ever taken an Uber, participated in the Draw, engaged with your bank, or ordered a coffee through the Starbucks app, you have experienced a service that must have a coordinated experience for the customer, the service provider, and any other stakeholders involved. Let us explore what specialized tools and processes are required to create these multi-faceted interactions. Prerequisites: CS147 or equivalent background in design thinking. Same as: CS 247S

SYMSYS 195T. Natural Language Processing & Text-Based Machine Learning in the Social Sciences. 4 Units.
Digital communications (including social media) are the largest data sets of our time, and most of it is text. Social scientists need to be able to digest small and big data sets alike, process it and extract psychological insight. This applied and project-focused course introduces students to a Python codebase developed to facilitate text analysis in the social sciences (see dlatk.wwbp.org – knowledge of Python is helpful but not required). The goal is to practice these methods in guided tutorials and project-based work so that the students can apply them to their own research contexts and be prepared to write up the results for publication. The course will provide best practices, as well as access to and familiarity with a Linux-based server environment to process text, including the extraction of words and phrases, topics and psychological dictionaries. We will also practice the use of machine learning based on text data for psychological assessment, and the further statistical analysis of language variables in R. Familiarity with Python is helpful but not required. Basic familiarity with R is expected. The ability to wrangle data into a spreadsheet-like format is expected. A basic introduction to SQL will be given in the course. Familiarity with SSH and basic Linux is helpful but not required. Understanding of regression is expected. Same as: PSYCH 290, SOC 281

SYMSYS 195U. Natural Language Understanding. 3-4 Units.
Project-oriented class focused on developing systems and algorithms for robust machine understanding of human language. Draws on theoretical concepts from linguistics, natural language processing, and machine learning. Topics include lexical semantics, distributed representations of meaning, relation extraction, semantic parsing, sentiment analysis, and dialogue agents, with special lectures on developing projects, presenting research results, and making connections with industry. Prerequisites: one of LINGUIST 180/280, CS 124, CS 224N, or CS 224S. Same as: CS 224U, LINGUIST 188, LINGUIST 288

SYMSYS 195V. Data Visualization. 3-4 Units.
Techniques and algorithms for creating effective visualizations based on principles from graphic design, visual art, perceptual psychology, and cognitive science. Topics: graphical perception, data and image models, visual encoding, graph and tree layout, color, animation, interaction techniques, automated design. Lectures, reading, and project. Prerequisite: one of CS147, CS148, or equivalent. Same as: CS 448B

SYMSYS 196. Independent Study. 1-15 Unit.
Independent work under the supervision of a faculty member. Can be repeated for credit.

SYMSYS 200. Minds and Machines. 4 Units.
(Formerly SYMSYS 100). An overview of the interdisciplinary study of cognition, information, communication, and language, with an emphasis on foundational issues: What are minds? What is computation? What are rationality and intelligence? Can we predict human behavior? Can computers be truly intelligent? How do people and technology interact, and how might they do so in the future? Lectures focus on how the methods of philosophy, mathematics, empirical research, and computational modeling are used to study minds and machines. Students must take this course before being approved to declare Symbolic Systems as a major. All students interested in studying Symbolic Systems are urged to take this course early in their student careers. The course material and presentation will be at an introductory level, without prerequisites. Same as: CS 24, LINGUIST 35, PHIL 99, PSYCH 35, SYMSYS 1

SYMSYS 201. Digital Technology, Society, and Democracy. 3 Units.
The impact of information and communication technologies on social and political life. Interdisciplinary. Classic and contemporary readings focusing on topics such as social networks, virtual versus face-to-face communication, the public sphere, voting technology, and collaborative production. Prerequisite: Completion of a course in psychology, communication, human-computer interaction, or a related discipline, or consent of the instructor.

SYMSYS 202. Theories of Consciousness. 3 Units.
Are fish conscious? Are fetuses? Could we build a conscious computer? Much of the philosophical work on consciousness has focused on whether consciousness is wholly physical, but that question is orthogonal to the more specific questions about consciousness that most of us really care about. To answer those questions, we need a theory of how consciousness works in our world. Philosophers and scientists have put forward a spectrum of different candidates, from very abstract, philosophical theories through theories more informed by cognitive psychology down to neural and even quantum theories. In this seminar, students will learn about the major theories of consciousness as well as conceptual issues that arise on different approaches. Particularly important will be the question of how we might gain empirical evidence for a theory of consciousness.

SYMSYS 203. Cognitive Science Perspectives on Humanity and Well-Being. 3 Units.
In recent years, cognitive scientists have turned more attention to questions that have traditionally been investigated by historians, political scientists, sociologists, and anthropologists, e.g. What are the sources of conflict and disagreement between people? What drives or reduces violence and injustice? What brings about or is conducive to peace and justice? In this advanced seminar, we will read and discuss works by psychologists, neuroscientists, philosophers, and others, which characterize this growing research area among those who study minds, brains, and behavior. Required: Completion of a course in psychology beyond the level of Psych 1, or consent of the instructor.

SYMSYS 205. The Philosophy and Science of Perception. 3 Units.
Our senses tell us about our immediate environment, but what exactly do they tell us? Our color experiences tell us that the things around us have color properties, but what in the world are color properties? Do we visually represent absolute size as well as relative size? When we see an apple, do we literally see it as an apple, or do we infer that it is an apple based on its color and shape? Can we expect to see affect what we actually see? In this seminar we will bring both philosophical and empirical perspectives to bear on these and other issues related to figuring out just how our perceptual experiences represent the world as being. Prerequisite: PHIL 80 or permission of the instructor.

SYMSYS 207. Conceptual Issues in Cognitive Science. 3 Units.
This seminar will cover a selection of foundational issues in cognitive science. Topics may include modularity, representation, connectionism, neuroscience and free will, neuroimaging, implants, sensory experience, the nature of information, and consciousness. Course is limited to 15 students. Prerequisite: Phil 80, or permission of the instructor.
SYMSYS 208. Computer Machines and Intelligence. 3 Units.
It has become common for us to see in the media news about computer winning a masters in chess, or answering questions on the Jeopardy TV show, or the impact of AI on health, transportation, education, in the labor market and even as an existential threat to mankind. This interest in AI gives rise questions such as: Is it possible for a computer to think? What is thought? Are we computers? Could machines feel emotions or be conscious? Curiously, there is no single, universally accepted definition of Artificial Intelligence. However in view of the rapid dissemination of AI these questions are important not only for experts, but also for all other members of society. This course is intended for students from different majors interested in learn how the concept of intelligent machine is understood by the researchers in AI. We will study the evolution of AI research, its different approaches, with focus on the tests developed to verify if a machine is intelligent or not. In addition, we will examine the philosophical problems associated with the concept of intelligent machine. The topics covered will include: Turing test, symbolic AI, connectionist AI, sub- symbolic AI, Strong AI and Weak AI, AI singularity, unconventional computing, rationality, intentionality, representation, machine learning, and the possibility of conscious machines.

SYMSYS 212. Challenges for Language Systems. 3-4 Units.
Parallel exploration of philosophical and computational approaches to modeling the construction of linguistic meaning. In philosophy of language: lexical sense extension, figurative speech, the semantics/pragmatics interface, contextualism debates. In CS: natural language understanding, from formal compositional models of knowledge representation to statistical and deep learning approaches. We will develop an appreciation of the complexities of language understanding and communication; this will inform discussion of the broader prospects for Artificial Intelligence. Special attention will be paid to epistemological questions on the nature of linguistic explanation, and the relationship between theory and practice. PREREQUISITES: PHIL80; some exposure to philosophy of language and/or computational language processing is recommended.
Same as: SYMSYS 112

SYMSYS 245. Cognition in Interaction Design. 3 Units.
Note: Same course as 145 which is no longer active. Interactive systems from the standpoint of human cognition. Topics include skill acquisition, complex learning, reasoning, language, perception, methods in usability testing, special computational techniques such as intelligent and adaptive interfaces, and design for people with cognitive disabilities. Students conduct analyses of real world problems of their own choosing and redesign/analyze a project of an interactive system. Limited enrollment seminar taught in two sections of approximately ten students each. Admission to the course is by application to the instructor, with preference given to Symbolic Systems students of advanced standing. Recommended: a course in cognitive psychology or cognitive anthropology.

SYMSYS 255. Building Digital History: Informatics of Social Movements and Protest. 3-5 Units.
A participatory course focused on the online representation of oral and archival history research. This year’s thematic focus is the design and evaluation of history websites focused on social movements and protest. We will survey the field of digital history and its application to social movement research and teaching. The course will utilize materials developed in the 2014 version of the course, which focused on the history of student activism at Stanford. Class will apply lessons from digital history practice and theory to the design of an online repository and community for the collaborative representation and discussion of social movement history at Stanford, and to the further development of source material in a future version of the class. Topics will include participatory design, studies of historical learning, archiving issues, data integrity, and fair representation of different viewpoints, among others.

SYMSYS 255A. Building Digital History: Social Movements and Protest at Stanford. 1 Unit.
Lectures-only version of Symsys 255.

SYMSYS 271. Group Democracy. 2-4 Units.
This seminar will explore theoretical, empirical, and practical approaches to groups that come together around a common purpose or interest. Emphasis is on democratically structured, non-hierarchical and non-institutional decision making, e.g. by grassroots activists, student, or neighborhood organizations. Parliamentary, consensus, and informal procedures. How do groups form? How do they deliberate and make decision? What are the principles underlying different models for group process, and how well do different procedures work in practice? How do culture and identity affect the working of a group? And how are social technologies used? Readings from different disciplines and perspectives. Course is limited to 20 students. Prerequisite: A course in social psychology, decision making or group sociology. This course must be taken for a minimum of 3 units and a letter grade to be eligible for Ways credit.

SYMSYS 275. Collective Behavior and Distributed Intelligence. 3 Units.
This course will explore possibilities for student research projects based on presentations of faculty research. We will cover a broad range of topics within the general area of collective behavior, both natural and artificial. Students will build on faculty presentations to develop proposals for future projects.
Same as: BIO 175

SYMSYS 280. Symbolic Systems Research Seminar. 1 Unit.
A mixture of public lectures of interest to Symbolic Systems students (the Symbolic Systems Forum) and student-led meetings to discuss research in Symbolic Systems. Can be repeated for credit. Open to both undergraduates and Master's students. First meeting is the second Monday of the quarter.

SYMSYS 290. Master's Degree Project. 1-15 Unit.

SYMSYS 291. Master's Program Seminar. 1 Unit.
Enrollment limited to students in the Symbolic Systems M.S. degree program. May be repeated for credit.

SYMSYS 295D. Research in Digital Democracy. 3-4 Units.
Digital democracy refers to social activity that is organized democratically at a group, institutional, or societal level, and that takes place within or is augmented by digital technology. This is a project-based research seminar designed to teach students methods for studying digital democracy, as well as collaborating in a group, the organization of a research project, and academic writing. The first few weeks of the course will be an overview of digital democracy research and its methods, as well as a time for students to organize into a group research project, The remainder of the class (about 7 weeks) will be spent performing and writing up the research for a targeted publication venue. Application required for enrollment. Prerequisite: At least one course in empirical methods or statistics. Prerequisites: At least one course in empirical methods or statistics.
Same as: SYMSYS 195D

SYMSYS 296. Independent Study. 1-15 Unit.
Independent work under the supervision of a faculty member. Can be repeated for credit.

SYMSYS 297. Teaching in Symbolic Systems. 1-5 Unit.
Leading sections, grading, and/or other duties of teaching or helping in supervising the course in which you are teaching or assisting.
Optional for students selected as Undergraduate Advising Fellows in the Symbolic Systems Program. AFs work with program administrators to assist undergraduates in the Symbolic Systems major or minor, in course selection, degree planning, and relating the curriculum to a career or life plan, through advising and events. Meeting with all AFs for an hour once per week under the direction of the Associate Director. Requires a short reflective paper at the end of the quarter on what the AF has learned about advising students in the program. Repeatable for credit. May not be taken by students who receive monetary compensation for their work as an AF.

SYMSYS 299. Curricular Practical Training. 1 Unit.
Students obtain employment in a relevant research or industrial activity to enhance their professional experience consistent with their degree programs. Meets the requirements for curricular practical training for students on F-1 visas. Students submit a concise report detailing work activities, problems worked on, and key results. May be repeated for credit. Prerequisite: qualified offer of employment and consent of advisor.