
The observation that both human beings and computers can manipulate symbols lies at the heart of Symbolic Systems, an interdisciplinary program focusing on the relationship between natural and artificial systems that represent, process, and act on information. Computer programs, natural languages, the human mind, and the Internet embody concepts whose study forms the core of the Symbolic Systems curriculum, such as computation, representation, communication, and intelligence. A body of knowledge and theory has developed around these notions, from disciplines such as philosophy, computer science, linguistics, psychology, statistics, neurobiology, and communication. Since the invention of computers, researchers have been working across these disciplines to study questions such as: in what ways are computers and computer languages like human beings and their languages; how can the interaction between people and computers be made easier and more beneficial?

The core requirements of the Symbolic Systems Program (SSP) include courses in symbolic logic, the philosophy of mind, formal linguistics, cognitive psychology, programming, the mathematics of computation, statistical theory, artificial intelligence, and interdisciplinary approaches to cognitive science. These courses prepare students 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. 25) and a Minor in Symbolic Systems (p. 25). 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://www.dhs.gov/eligible-cip-codes-for-the-stem-opt-extension) list of STEM programs. Depending on the plan of study, Sym Sys students can be classified as studying Cognitive Science (2010 CIP Code 30.2501) and/or Informatics (2010 CIP Code 11.0104).

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/undergraduatesundergradadvisingfellowsoffice-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.
- A hold is placed on Winter Quarter registration for juniors who do not have a concentration advisor by Autumn Quarter of their junior year.
(See the COVID-19 Policies (p. 28) tab for a one-year extension to Winter Quarter for this requirement.)

- Any individual with an ongoing instructional 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, including a statement of how the student plans to fulfill the capstone requirement of the major. Changes to capstone plans require the approval of 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. 5) 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 for 3 units or more, 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), except as modified by the COVID-19 policies in effect during 2020-21. 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/undergraduatesminor-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. Preparations 4

These courses should be completed early in the major.

a. Gateway Course
SYMSYS 1 Minds and Machines 4

b. Single Variable Calculus 10
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 3-6
One of the following:
CME 100 Vector Calculus for Engineers 5
CME 100A Vector Calculus for Engineers, ACE 6
MATH 51 Linear Algebra, Multivariable Calculus, and Modern Applications 5
MATH 51A Linear Algebra, Multivariable Calculus, and Modern Applications, ACE 6
MATH 61CM Modern Mathematics: Continuous Methods 5
MATH 61DM Modern Mathematics: Discrete Methods 5
d. Further Study in Multivariate Systems 3-5
Optional, but recommended, and may be used as contingent electives in a concentration. One or more of the following courses, which may be needed as preparation for some Core and Concentrations electives, may be used as options and other advanced courses in the major.
CME 102 Ordinary Differential Equations for Engineers (and optionally CME 104) 5
CME 102A Ordinary Differential Equations for Engineers, ACE (, ACE, and (optionally) CME 104A, ACE) 6
CME 104 Linear Algebra and Partial Differential Equations for Engineers 5
ENGR 108 Introduction to Matrix Methods (formerly CME 103) 3-5
MATH 52 Integral Calculus of Several Variables 5
MATH 53 Ordinary Differential Equations with Linear Algebra 5
MATH 62CM Modern Mathematics: Continuous Methods 5
MATH 62DM Modern Mathematics: Discrete Methods 5
MATH 63CM Modern Mathematics: Continuous Methods 5
MATH 104 Applied Matrix Theory 3
MATH 113 Linear Algebra and Matrix Theory 3

2. Breadth Requirements 9-15

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

a. Philosophical Analysis

i. 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 4

ii. Writing in the Major (WIM) course
PHIL 80 Mind, Matter, and Meaning 5

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 172
History of Modern Moral Philosophy

### PHIL 173B
Metaethics

### PHIL 175
Philosophy of Law

### PHIL 180
Metaphysics

### PHIL 180A
Philosophy of Language

### PHIL 182

### PHIL 182A
Naturalizing Representation

### PHIL 182H
Truth

### PHIL 184
Topics in Epistemology

### PHIL 186
Philosophy of Mind

### PHIL 187
Philosophy of Action

### PHIL 189G
Fine-Tuning Arguments for God's Existence

### SYMSYS 205
The Philosophy and Science of Perception

### SYMSYS 207
Conceptual Issues in Cognitive Science

#### b. Formal Methods
Courses that focus on rigorous definitions, axioms, theorems, and proofs, and their use in developing mathematical theories and meta-theories. Each of the following:

##### i. Formal Logic
One of the following:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS 157</td>
<td>Computational Logic</td>
<td>3</td>
</tr>
<tr>
<td>PHIL 150</td>
<td>Mathematical Logic</td>
<td>4</td>
</tr>
<tr>
<td>PHIL 151</td>
<td>Metalogic (Prerequisite: PHIL 150 or instructor permission)</td>
<td>4</td>
</tr>
</tbody>
</table>

##### ii. Theory of Computation. One of the following:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</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>
</tbody>
</table>

##### iii. Probability Theory and Statistics
A course that covers the theory of probability and is grounded in multivariable calculus. One of the following:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<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>
</tbody>
</table>

#### c. Computational Methods
Courses that focus on software design, data structures, algorithms, development, applications, evaluation, and simulation. Each of the following:

##### i. Programming 1
One of the following:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS 106A</td>
<td>Programming Methodology</td>
<td>3-5</td>
</tr>
</tbody>
</table>

Equivalent preparation, as evidenced by successful completion of CS 106B or 106X

##### ii. Programming II

### One of the following:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS 106B</td>
<td>Programming Abstractions</td>
<td>3-5</td>
</tr>
<tr>
<td>CS 106X</td>
<td>Programming Abstractions (Accelerated)</td>
<td>3-5</td>
</tr>
</tbody>
</table>

#### iii. A post CS 106B course covering one or more broad computational methods with a programming component.

### One of the following:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<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 (Plus one of the following)</td>
<td>3-5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS 193A</td>
<td>Android Programming</td>
<td>3</td>
</tr>
<tr>
<td>CS 193C</td>
<td>Client-Side Internet Technologies</td>
<td>3</td>
</tr>
<tr>
<td>CS 193P</td>
<td>iOS Application Development</td>
<td>3</td>
</tr>
<tr>
<td>CS 193X</td>
<td>Web Programming Fundamentals</td>
<td>3</td>
</tr>
<tr>
<td>CS 194H</td>
<td>User Interface Design Project</td>
<td>3-4</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.

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>PSYCH 1</td>
<td>Introduction to Psychology</td>
<td>5</td>
</tr>
</tbody>
</table>

##### ii. An introductory area course in cognition, language, and neuroscience.

One of the following:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIO 150</td>
<td>Human Behavioral Biology</td>
<td>5</td>
</tr>
<tr>
<td>LINGUIST 145</td>
<td>Introduction to Psycholinguistics</td>
<td>4</td>
</tr>
<tr>
<td>LINGUIST 150</td>
<td>Language and Society</td>
<td>3-4</td>
</tr>
<tr>
<td>PSYCH 30</td>
<td>Introduction to Perception</td>
<td>4</td>
</tr>
<tr>
<td>PSYCH 45</td>
<td>Introduction to Learning and Memory</td>
<td>3</td>
</tr>
<tr>
<td>PSYCH 50</td>
<td>Introduction to Cognitive Neuroscience</td>
<td>4</td>
</tr>
<tr>
<td>PSYCH 60</td>
<td>Introduction to Developmental Psychology</td>
<td>3</td>
</tr>
<tr>
<td>PSYCH 70</td>
<td>Self and Society: Introduction to Social Psychology</td>
<td>4</td>
</tr>
<tr>
<td>PSYCH 75</td>
<td>Introduction to Cultural Psychology</td>
<td>5</td>
</tr>
<tr>
<td>PSYCH 141</td>
<td>Cognitive Development</td>
<td>3</td>
</tr>
<tr>
<td>PSYCH 154</td>
<td>Judgment and Decision-Making</td>
<td>3</td>
</tr>
</tbody>
</table>

##### iii. Linguistic Theory
A course introducing a core area of theoretical inquiry in linguistics. One of the following:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>LINGUIST 105</td>
<td>Phonetics</td>
<td>4</td>
</tr>
<tr>
<td>LINGUIST 110</td>
<td>Introduction to Phonology</td>
<td>4</td>
</tr>
<tr>
<td>LINGUIST 120</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LINGUIST 130A</td>
<td>Introduction to Semantics and Pragmatics</td>
<td>4</td>
</tr>
<tr>
<td>LINGUIST 130B</td>
<td>Introduction to Lexical Semantics</td>
<td>3-4</td>
</tr>
</tbody>
</table>

#### Additional approved undergraduate courses offered on a semi-regular basis:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>LINGUIST 21N</td>
<td>Linguistic Diversity and Universals: The Principles of Language Structure</td>
<td>3</td>
</tr>
<tr>
<td>LINGUIST 30N</td>
<td>Linguistic Meaning and the Law</td>
<td>3</td>
</tr>
<tr>
<td>LINGUIST 121A</td>
<td>The Syntax of English</td>
<td>4</td>
</tr>
<tr>
<td>LINGUIST 121B</td>
<td>Crosslinguistic Syntax</td>
<td>4</td>
</tr>
<tr>
<td>LINGUIST 134A</td>
<td>The Structure of Discourse: Theory and Applications</td>
<td>2-4</td>
</tr>
<tr>
<td>LINGUIST 160</td>
<td>Introduction to Language Change</td>
<td>2-4</td>
</tr>
</tbody>
</table>
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:

- CS 147: Introduction to Human-Computer Interaction Design 3-5
- CS 229: Machine Learning 3-4
- LINGUIST 130A: Introduction to Semantics and Pragmatics 4
- LINGUIST 180: From Languages to Information 3-4
- PHIL 152: Computability and Logic 4
- PHIL 154: Modal Logic 4
- PHIL 167D: Philosophy of Neuroscience 4
- PHIL 181: Philosophy of Language 4
- PSYCH 204: Computation and Cognition: The Probabilistic Approach 3
- PSYCH 209: Neural Network Models of Cognition 4

ii. Any other course on the full list of courses approved for this requirement below.

3. Experiential Requirements

Each of the following:

a. Advanced Small Seminar Requirement.

An approved course which (a) builds on the Core Preparations 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

An approved project course with a SYMSYS listing in the 195-series. Any of the following:

- SYMSYS 195A: Design for Artificial Intelligence 3-4
- SYMSYS 195B: Design for Behavior Change 3-4
- SYMSYS 195D: Research in Digital Democracy 3-4
- SYMSYS 195E: Experimental Methods 3
- SYMSYS 195G: Introduction to Game Design 3-4
- SYMSYS 195I: Image Systems Engineering 1-3
- SYMSYS 195L: Methods in Psycholinguistics 4
- SYMSYS 195N: Natural Language Processing with Deep Learning 3-4
- SYMSYS 195S: Service Design 3-4
- SYMSYS 195U: Natural Language Understanding 3-4
- SYMSYS 195V: Data Visualization 3-4

Supervised Research

Taken with a faculty member on an approved symbolic-systems related project, taken as SYMSYS 196: Independent Study, or a department-based directed research course.

SYMSYS 192: Symbolic Systems in Practice (must be taken in conjunction with an approved internship or service project)

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. Units must 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) 1-5

An approved project course with a SYMSYS listing in the 195-series

(See list under “Practicum” above - 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 (may be either the second quarter of a 2-quarter course or a one-quarter course)

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

Total Units 75-90

Full List of Cross-Area Requirement Courses

Cross-Area Requirement

The full list of approved courses for the Cross-Area Requirement. 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

Formal Methods and Computational Methods

- CS 151: Logic Programming 3
- CS 154: Introduction to the Theory of Computation 3-4
- CS 161: Design and Analysis of Algorithms 3-5
- CS 229: Machine Learning 3-4
- CS 238: Decision Making under Uncertainty 3-4
- LINGUIST 130A: Introduction to Semantics and Pragmatics 4
- LINGUIST 180: From Languages to Information 3-4
- PHIL 152: Computability and Logic 4
- PHIL 154: Modal Logic 4
Concentration Areas

Please note: the concentrations areas are being revised, and new ones being added.

Applied Logic

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

Symbolic Systems majors completing the new Core requirements effective for 2020-2021 must complete the following requirements to qualify for a Concentration in Applied Logic. All courses must be taken for 3 units of more.

Metalogic 3-5

PHIL 151 Metalogic

Computability 3-5

Select one of the following:

CS 154 Introduction to the Theory of Computation
PHIL 152 Computability and Logic

Computational Approaches to Logic 3-5

Select one of the following:

CS 151 Logic Programming
CS 157 Computational Logic

Set Theory 3-5

MATH 161 Set Theory

Integrative Requirement. Must be completed no earlier than the Junior Year. 3-5

i. Any of the Standard Options for all Concentrations specified under the Core Capstone requirement, or

ii. A Concentration-Specific Integrative Course: A course that integrates the themes of the Concentration with the Core requirements. Select one of the following (with more options to be added as they are approved – some options may be removed if they are included in the list of SYMSYS 195* project courses, in order to avoid redundancy with the Standard Options).

CS 151 Logic Programming
CS 163 The Practice of Theory Research
CS 204 Computational Law
CS 227B General Game Playing
CS 228 Probabilistic Graphical Models: Principles and Techniques

CS 242 Programming Languages
CS 254 Computational Complexity
CS 358A Programming Language Foundations
LINGUIST 130A Introduction to Semantics and Pragmatics
LINGUIST 230B Advanced Semantics
PHIL 154 Modal Logic
PHIL 162 Philosophy of Mathematics
PHIL 184B Formal Epistemology
PHIL 351D Measurement Theory
PHIL 356C Logic and Artificial Intelligence
PHIL 359 Logic Spring Seminar
PSYCH 204 Computation and Cognition: The Probabilistic Approach
PSYCH 293 What makes a good explanation? Psychological and philosophical perspectives

Contingent Electives 3-5

If any of requirements 1-4 are fulfilled with courses taken for Core requirements, then additional approved Contingent Elective courses must be completed to total 5 courses beyond those that are taken for the Core. These electives can be one or more courses from any of the areas above, or which are approved for a Core requirement that the student has fulfilled with a different course, or any of the following:

CS 254B Computational Complexity II
LINGUIST 230C Advanced Topics in Semantics & Pragmatics
MATH 56 Proofs and Modern Mathematics

Additional courses may be added here in the future.

Total Units

15-25

Artificial Intelligence

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

Symbolic Systems majors completing the new Core requirements effective for 2020-21 must complete the following requirements to qualify for a Concentration in Artificial Intelligence. All courses must be taken for 3 units of more.
Students in this Concentration are urged to take CS 161, either for the Core Cross-Area Requirement, or as a Contingent Elective, and prior to taking CS 221.

**Programming** 3-5

Select one of the following:

- CS 107 Computer Organization and Systems
- CS 107E Computer Systems from the Ground Up

**Introduction** 3-5

- CS 221 Artificial Intelligence: Principles and Techniques

**Artificial Intelligence Depth** 3-5

Two courses chosen from the "select" list of AI courses (category B of the MSCS AI Track):

- CS 223A Introduction to Robotics
- CS 224N Natural Language Processing with Deep Learning
- CS 224S Spoken Language Processing
- CS 224U Natural Language Understanding
- CS 224W Machine Learning with Graphs
- CS 228 Probabilistic Graphical Models: Principles and Techniques
- CS 229 Machine Learning
- CS 231A Computer Vision: From 3D Reconstruction to Recognition
- CS 231N Convolutional Neural Networks for Visual Recognition
- CS 234 Reinforcement Learning
- CS 238 Decision Making under Uncertainty

**Integrative Requirement** 3-5

Must be completed no earlier than the Junior Year

i. Any of the Standard Options for all Concentrations specified under the Core Capstone requirement, or

ii. A Concentration-Specific Integrative Course: A course that integrates the themes of the Concentration with the Core requirements. Select one of the following (with more options to be added as they are approved -- some options may be removed if they are included in the list of SYMSYS 195* project courses, in order to avoid redundancy with the Standard Options).

- COMM 324 Language and Technology
- COMM 326 Advanced Topics in Human Virtual Representation
- CS 131 Computer Vision: Foundations and Applications
- CS 181 Computers, Ethics, and Public Policy
- CS 182 Ethics, Public Policy, and Technological Change
- CS 229M Machine Learning Theory
- CS 325B Data for Sustainable Development
- CS 329D Machine Learning Under Distributional Shifts
- CS 379C Computational Models of the Neocortex
- LINGUIST 180 From Languages to Information
- MUSIC 220C Research Seminar in Computer-Generated Music
- PHIL 356C Logic and Artificial Intelligence
- PHIL 359 Logic Spring Seminar
- PSYCH 164 Brain decoding
- PSYCH 204 Computation and Cognition: The Probabilistic Approach
- PSYCH 209 Neural Network Models of Cognition

**Contingent Electives** 3-5

If any of requirements 1-3 are fulfilled with courses taken for Core requirements, then additional approved Contingent Elective courses must be completed to total 5 courses beyond those that are taken for the Core. These electives can be one or more courses from any of the areas above, or which are approved for a Core requirement that the student has fulfilled with a different course, or any of the following:

- BIOMedin 210 Modeling Biomedical Systems
- BIOMedin 214 Representations and Algorithms for Computational Molecular Biology
- CS 217 Hardware Accelerators for Machine Learning
- CS 227B General Game Playing
- CS 236 Deep Generative Models
- CS 246 Mining Massive Data Sets
- CS 330 Deep Multi-task and Meta Learning
- CS 348I Computer Graphics in the Era of AI
- CS 348K Visual Computing Systems
- LAW 4039 Regulating Artificial Intelligence
- MS&E 135 Networks
- MS&E 234 Data Privacy and Ethics
- MUSIC 220B Compositional Algorithms, Psychoacoustics, and Computational Music
- MUSIC 220C Research Seminar in Computer-Generated Music
- PHIL 20N Philosophy of Artificial Intelligence
- STATS 200 Introduction to Statistical Inference
- STATS 202 Data Mining and Analysis
- STATS 315A Modern Applied Statistics: Learning
- STATS 315B Modern Applied Statistics: Data Mining

**Total Units** 15-25

**Biomedical Applications**

See also the Symbolic Systems website (https://symsys.stanford.edu/undergraduateconcentrations/biomedical-applications-biomed-concentration/).

Symbolic Systems majors completing the new Core requirements effective for 2020-2021 must complete the following requirements to qualify for a Concentration in Biomedical Applications. All courses must be taken for 3 units of more.

**Philosophical and Ethical Inquiry** 3-5

For example, any of the following:

- HUMBIO 174 Foundations of Bioethics
- HUMBIO 178A Intro to Disability Studies: Disability and Technology
- NBIO 101 Social and Ethical Issues in the Neurosciences
- PHIL 85 Topics in Philosophy of Medicine
<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHIL 134A</td>
<td>Phenomenology: Animals</td>
</tr>
<tr>
<td>PHIL 167D</td>
<td>Philosophy of Neuroscience</td>
</tr>
<tr>
<td>PHIL 168M</td>
<td>Biological Individuality</td>
</tr>
<tr>
<td>PHIL 178M</td>
<td>Introduction to Environmental Ethics</td>
</tr>
<tr>
<td>PHIL 360</td>
<td>Grad Seminar: Philosophy of Neuroscience</td>
</tr>
<tr>
<td>PHIL 368A</td>
<td>Topics in Neuroscience</td>
</tr>
<tr>
<td>SYMSYS 202</td>
<td>Theories of Consciousness</td>
</tr>
<tr>
<td>SYMSYS 205</td>
<td>The Philosophy and Science of Perception</td>
</tr>
</tbody>
</table>

**Theoretical and Mathematical Approaches** 3-5

For example, any of the following:

- BIO 183: Theoretical Population Genetics
- BIO 223: Quantitative Evolutionary Dynamics and Genomics
- BIOMEDIN 219: Mathematical Models and Medical Decisions

**Computational and Design Methods** 3-5

For example, any of the following:

- BIODS 215: Topics in Biomedical Data Science: Large-scale inference
- BIOMEDIN 219: Mathematical Models and Medical Decisions
- BIOMEDIN 219: Mathematical Models and Medical Decisions
- BIOMEDIN 220: Computer Modeling

**Experimental and Observational Science**

- BIO 81: Introduction to Ecology
- BIO 82: Genetics
- BIO 84: Physiology
- BIO 150: Human Behavioral Biology
- BIO 151: Mechanisms of Neuron Death

**Integrative Requirement** 3-5

Must be completed no earlier than the Junior Year.

1. Any of the Standard Options for all Concentrations specified under the Core Capstone requirement, or
2. A Concentration-Specific Integrative Course: A course that integrates the themes of the Concentration with the Core requirements. Select one of the following (with more options to be added as they are approved -- some options may be removed if they are included in the list of SYMSYS 195* project courses, in order to avoid redundancy with the Standard Options).

**Additional Courses**

- BIOMEDIN 210: Modeling Biomedical Systems
- BIOMEDIN 220: Artificial Intelligence in Healthcare
- BIOMEDIN 260: Computational Methods for Biomedical Image Analysis and Interpretation
- BIOMEDIN 273A: The Human Genome Source Code
- BIOMEDIN 273B: Deep Learning in Genomics and Biomedicine
- BIOMEDIN 279: Computational Biology: Structure and Organization of Biomolecules and Cells
- COMM 326: Advanced Topics in Human Virtual Representation
- CS 325B: Data for Sustainable Development
- CS 372: Artificial Intelligence for Disease Diagnosis and Information Recommendations
- CS 379C: Computational Models of the Neocortex
- PSY 124: Brain Plasticity
- PSY 151: Human Behavioral Ethics
- PHIL 167D: Philosophy of Neuroscience
- PHIL 168M: Biological Individuality
- PHIL 178M: Grad Seminar: Philosophy of Neuroscience
- PSY 223B: Topics in Neurodiversity: Design Thinking Approaches
PSYCH 169 Advanced Seminar on Memory
PSYCH 202 Cognitive Neuroscience
PSYCH 204A Human Neuroimaging Methods
PSYCH 204B Computational Neuroimaging
PSYCH 232 Brain and Decision
PSYCH 254 Affective Neuroscience
PSYCH 273 Changing Mindsets and Contexts: How to Create Authentic, Lasting Improvement
STATS 220 Machine Learning Methods for Neural Data Analysis
SYMSYS 245 Cognition in Interaction Design

Contingent Electives
If any of requirements 1-4 are fulfilled with courses taken for Core requirements, then additional approved Contingent Elective courses must be completed to total 5 courses beyond those that are taken for the Core. These electives can be one or more courses from any of the areas above, or which are approved for a Core requirement that the student has fulfilled with a different course, or any of the following:

Additional courses may be added here in the future.

Total Units 15-25

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

Symbolic Systems majors completing the new Core requirements effective for 2020-2021 must complete the following requirements to qualify for a Concentration in Cognitive Science. All courses must be taken for 3 units of more.

Cognitive Neuroscience 3-5
Select one of the following:
PSYCH 30 Introduction to Perception
PSYCH 45 Introduction to Learning and Memory
PSYCH 50 Introduction to Cognitive Neuroscience

Inferential Statistics 3-5
Select one of the following:
ANTHRO 116 Data Analysis for Quantitative Research
MS&E 125 Introduction to Applied Statistics
MS&E 226 Fundamentals of Data Science: Prediction, Inference, Causality
PSYCH 10 Introduction to Statistical Methods: Pre calculus
PSYCH 253 Advanced Statistical Modeling
SOC 180B Introduction to Data Analysis
STATS 101 Data Science 101
STATS 110 Statistical Methods in Engineering and the Physical Sciences
STATS 191 Introduction to Applied Statistics
STATS 200 Introduction to Statistical Inference
STATS 202 Data Mining and Analysis

Research Methods 3-5
A course on research practices and/or methods that are commonly used for studying cognition, language, and the brain. For example, one of the following:
CS 107 Computer Organization and Systems
CS 129 Applied Machine Learning
CS 229 Machine Learning
LINGUIST 180 From Languages to Information
LINGUIST 188 Natural Language Understanding

LINGUIST 245B Methods in Psycholinguistics
PHIL 167D Philosophy of Neuroscience
PSYCH 164 Brain decoding
PSYCH 187 Research Methods in Cognition & Development
PSYCH 204 Computation and Cognition: The Probabilistic Approach
PSYCH 209 Neural Network Models of Cognition
PSYCH 221 Image Systems Engineering
PSYCH 240A Curiosity in Artificial Intelligence
PSYCH 242 Theoretical Neuroscience
PSYCH 249 Large-Scale Neural Network Modeling for Neuroscience
PSYCH 251 Experimental Methods
PSYCH 253 Advanced Statistical Modeling
PSYCH 262 Measurement and the Study of Change in Social Science Research
STATS 220 Machine Learning Methods for Neural Data Analysis

Cognitive Science Depth 3-5
For example, one of the following courses:
BIO 150 Human Behavioral Biology
COMM 108 Media Processes and Effects
COMM 322 Advanced Studies in Behavior and Social Media
CS 131 Computer Vision: Foundations and Applications
CS 154 Introduction to the Theory of Computation
CS 224N Natural Language Processing with Deep Learning
CS 227B General Game Playing
CS 228 Probabilistic Graphical Models: Principles and Techniques
CS 229M Machine Learning Theory
CS 231A Computer Vision: From 3D Reconstruction to Recognition
CS 234 Reinforcement Learning
CS 238 Decision Making under Uncertainty
ECON 160 Game Theory and Economic Applications
EDUC 266 Educational Neuroscience
EDUC 368 Cognitive Development in Childhood and Adolescence
LINGUIST 105 Phonetics
LINGUIST 110 Introduction to Phonology
LINGUIST 140 Learning to Speak: An Introduction to Child Language Acquisition
LINGUIST 180 From Languages to Information
LINGUIST 188 Natural Language Understanding
LINGUIST 236 Seminar in Semantics: Conditionals
MUSIC 251 Psychophysics and Music Cognition
NBIO 206 The Nervous System
PHIL 82T Philosophy of Cognitive Science
PHIL 152 Computability and Logic
PHIL 153L Computing Machines and Intelligence
PHIL 154 Modal Logic
PHIL 167D Philosophy of Neuroscience
PHIL 181 Philosophy of Language
PHIL 184 Topics in Epistemology
PHIL 184B Formal Epistemology
**Integrative Requirement**  
3-5  
Must be completed no earlier than the Junior Year.

i. Any of the Standard Options for all Concentrations specified under the Core Capstone requirement, or

ii. A Concentration-Specific Integrative Course: A course that integrates the themes of the Concentration with the Core requirements. Select one of the following (with more options to be added as they are approved — some options may be removed if they are included in the list of SYMSYS 195* project courses, in order to avoid redundancy with the Standard Options).

<table>
<thead>
<tr>
<th>COURSE</th>
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<tbody>
<tr>
<td>SYMSYS 208</td>
<td>Advanced Topics in Human Virtual Representation</td>
</tr>
<tr>
<td>CS 131</td>
<td>Computer Vision: Foundations and Applications</td>
</tr>
<tr>
<td>CS 181</td>
<td>Computers, Ethics, and Public Policy</td>
</tr>
<tr>
<td>CS 182</td>
<td>Ethics, Public Policy, and Technological Change</td>
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<tr>
<td>CS 221</td>
<td>Artificial Intelligence: Principles and Techniques</td>
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<td>CS 230</td>
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<td>Data for Sustainable Development</td>
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<tr>
<td>CS 379C</td>
<td>Computational Models of the Neocortex</td>
</tr>
<tr>
<td>EE 104</td>
<td>Introduction to Machine Learning</td>
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<tr>
<td>LINGUIST 180</td>
<td>From Languages to Information</td>
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<tr>
<td>MUSIC 220C</td>
<td>Research Seminar in Computer-Generated Music</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>
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<td>PHIL 134A</td>
<td>Phenomenology: Animals</td>
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<td>PHIL 356C</td>
<td>Logic and Artificial Intelligence</td>
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<td>Research Seminar on Logic and Cognition</td>
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<td>PSYCH 164</td>
<td>Brain decoding</td>
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<td>PSYCH 204</td>
<td>Computation and Cognition: The Probabilistic Approach</td>
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<tr>
<td>PSYCH 209</td>
<td>Neural Network Models of Cognition</td>
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<td>Image Systems Engineering</td>
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<td>PSYCH 232</td>
<td>Brain and Decision</td>
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<td>PSYCH 249</td>
<td>Large-Scale Neural Network Modeling for Neuroscience</td>
</tr>
<tr>
<td>PSYCH 250</td>
<td>High-level Vision: From Neurons to Deep Neural Networks</td>
</tr>
<tr>
<td>PSYCH 254</td>
<td>Affective Neuroscience</td>
</tr>
<tr>
<td>PSYCH 266</td>
<td>Current Debates in Learning and Memory</td>
</tr>
<tr>
<td>PSYCH 287</td>
<td>Brain Machine Interfaces: Science, Technology, and Application</td>
</tr>
<tr>
<td>PSYCH 293</td>
<td>What makes a good explanation? Psychological and philosophical perspectives</td>
</tr>
<tr>
<td>SYMSYS 203</td>
<td>Cognitive Science Perspectives on Humanity and Well-Being</td>
</tr>
<tr>
<td>SYMSYS 207</td>
<td>Conceptual Issues in Cognitive Science</td>
</tr>
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<td>SYMSYS 208</td>
<td>Computer Machines and Intelligence</td>
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</tbody>
</table>

**Contingent Electives**  
3-5  
**If any of requirements 1-4 are fulfilled with courses taken for Core requirements, then additional approved Contingent Elective courses must be completed to total 5 courses beyond those that are taken for the Core. These electives can be one or more courses from any of the areas above, or which are approved for a Core requirement that the student has fulfilled with a different course, or any of the following:**

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<tbody>
<tr>
<td>STATS 220</td>
<td>Machine Learning Methods for Neural Data Analysis</td>
</tr>
<tr>
<td>SYMSYS 202</td>
<td>Theories of Consciousness</td>
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<tr>
<td>SYMSYS 205</td>
<td>The Philosophy and Science of Perception</td>
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<td>Conceptual Issues in Cognitive Science</td>
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<td>SYMSYS 208</td>
<td>Computer Machines and Intelligence</td>
</tr>
</tbody>
</table>
Additional courses may be added here in the future.

**Total Units** 15-25

**Computational Foundations**

See also the Symbolic Systems website (https://symsys.stanford.edu/undergraduates/concentrations/computational-foundations-cofo-concentration/).

Symbolic Systems majors completing the new Core requirements effective for 2020-2021 must complete the following requirements to qualify for a Concentration in Computational Foundations. All courses must be taken for 3 units of more.

Students in this Concentration are strongly encouraged to take either CS 181 or CS 182 as part of the major, either for the Core Cross-Area Requirement, for the Capstone Integrative Requirement, as a Contingent Elective, or (in the case of CS 182) for the Core Introductory Philosophy requirement.

**Computer Systems I** 3-5

Select one of the following:
- CS 107 Computer Organization and Systems
- CS 107E Computer Systems from the Ground Up

**Computer Systems II** 3-5

Select one of the following:
- CS 110 Principles of Computer Systems
- CS 111 Operating Systems Principles

**Theory of Computation Depth** 3-5

Select one of the following:
- CS 154 Introduction to the Theory of Computation
- PHIL 154 Modal Logic

**Algorithms** 3-5

- CS 161 Design and Analysis of Algorithms

**Integrative Requirement** 3-5

Must be completed no earlier than the Junior Year.

- Any of the Standard Options for all Concentrations specified under the Core Capstone requirement, or
- A Concentration-Specific Integrative Course: A course that integrates the themes of the Concentration with the Core requirements. Select one of the following (with more options to be added as they are approved – some options may be removed if they are included in the list of SYMSYS 195* project courses, in order to avoid redundancy with the Standard Options).
  - CS 151 Logic Programming
  - CS 157 Computational Logic
  - CS 163 The Practice of Theory Research
  - CS 181 Computers, Ethics, and Public Policy
  - CS 182 Ethics, Public Policy, and Technological Change
  - CS 349T Project Lab: Video and Audio Technology for Live Theater in the Age of COVID
  - CS 379C Computational Models of the Neocortex
  - PHIL 154 Modal Logic
  - PHIL 359 Logic Spring Seminar
  - PSYCH 204 Computation and Cognition: The Probabilistic Approach

**Contingent Electives** 3-5

If any of requirements 1-4 are fulfilled with courses taken for Core requirements, then additional approved Contingent Elective courses must be completed to total 5 courses beyond those that are taken for the Core. These electives can be one or more courses from any of the areas above, or which are approved for a Core requirement that the student has fulfilled with a different course, or any of the following:

- Any course of 3 units or more, listed with a CS course number greater than 110, excluding CS 196 or CS 198.
- Any course of 3 units or more, listed with an EE course number.
- Any course of 3 units or more, listed with a MATH course number.
- Any course of 3 units or more, listed with a STATS course number.
- PHIL 20N Philosophy of Artificial Intelligence

**Total Units** 15-25

**Computational Social Science Concentration**

See also the Symbolic Systems website (https://symsys.stanford.edu/undergraduates/concentrations/computational-social-science-css-concentration/).

Symbolic Systems majors completing the new Core requirements effective for 2020-2021 must complete the following requirements to qualify for a Concentration in Computational Social Science. All courses must be taken for 3 units of more.

**Social Behavior** 3-5

An introductory course in a broad area of social science. Select one of the following:

- BIO 30 Ecology for Everyone
- BIO 81 Introduction to Ecology
- COMM 1 Introduction to Communication
- ECON 1 Principles of Economics
- ECON 46 Networks and Human Behavior
- ECON 50 Economic Analysis I
- ECON 160 Game Theory and Economic Applications
- ECON 178 Behavioral Economics
- ECON 180 Honors Game Theory
- LINGUIST 150 Language and Society
- MS&E 135 Networks
- MS&E 180 Organizations: Theory and Management
- MS&E 232 Introduction to Game Theory
- POLISCI 1 The Science of Politics
- POLISCI 120C American Political Institutions in Uncertain Times
- PSYCH 70 Self and Society: Introduction to Social Psychology
- PSYCH 154 Judgment and Decision-Making
- SOC 1 Introduction to Sociology
- SOC 126 Introduction to Social Networks
- SOC 130 Education and Society
- SOC 146 Introduction to Comparative Studies in Race and Ethnicity

**Statistical Interference** 3-5

An introductory course in statistical methods. Select one of the following:

- ECON 102A Introduction to Statistical Methods (Postcalculus) for Social Scientists
- MS&E 125 Introduction to Applied Statistics
- MS&E 226 Fundamentals of Data Science: Prediction, Inference, Causality
SOC 180B  Introduction to Data Analysis
STATS 110  Statistical Methods in Engineering and the Physical Sciences
STATS 191  Introduction to Applied Statistics
STATS 200  Introduction to Statistical Inference
STATS 202  Data Mining and Analysis

**Computational Data Methods**  3-5

A course in machine learning, natural language processing, and/or probabilistic computational inference. Select one of the following:

- CS 129  Applied Machine Learning
- CS 224N  Natural Language Processing with Deep Learning
- CS 224W  Machine Learning with Graphs
- CS 228  Probabilistic Graphical Models: Principles and Techniques
- CS 229  Machine Learning
- CS 230  Deep Learning
- CS 238  Decision Making under Uncertainty
- CS 246  Mining Massive Data Sets
- CS 448B  Data Visualization
- ECON 102B  Applied Econometrics
- LINGUIST 180  From Languages to Information
- LINGUIST 188  Natural Language Understanding
- PSYCH 204  Computation and Cognition: The Probabilistic Approach
- PSYCH 209  Neural Network Models of Cognition
- STATS 216  Introduction to Statistical Learning

**Social Data Science**  3-5

A course on applying statistical and computational methods to the study of social behavior. Select one of the following:

- COMM 106  Communication Research Methods
- COMM 173E  Data Challenge Lab
- ECON 102D  Econometric Methods for Public Policy Analysis and Business Decision-Making
- ECON 151  Tackling Big Questions Using Social Data Science
- EDUC 143  Introduction to Data Science
- MS&E 231  Introduction to Computational Social Science
- POLISCI 150A  Data Science for Politics
- POLISCI 150C  Causal Inference for Social Science
- PSYCH 290  Natural Language Processing & Text-Based Machine Learning in the Social Sciences
- SOC 180A  Foundations of Social Research
- SOC 194  Computational Undergraduate Research
- SOC 369  Social Network Methods

**Integrative Requirement**  3-5

Must be completed no earlier than the Junior Year.

i. Any of the Standard Options for all Concentrations specified under the Core Capstone requirement, or

ii. A Concentration-Specific Integrative Course: A course that integrates the themes of the Concentration with the Core requirements. Select one of the following (with more options to be added as they are approved – some options may be removed if they are included in the list of SYMSYS 195* project courses, in order to avoid redundancy with the Standard Options)

- COMM 322  Advanced Studies in Behavior and Social Media

**Contingent Electives**  3-5

If any of requirements 1-4 are fulfilled with courses taken for Core requirements, then additional approved Contingent Elective courses must be completed to total 5 courses beyond those that are taken for the Core. These electives can be one or more courses from any of the areas above, or which are approved for a Core requirement that the student has fulfilled with a different course, or any of the following:

- ANTHRO 116  Data Analysis for Quantitative Research
- ANTHRO 132D  Thinking Technology: Anthropological Perspectives
- BIO 61  Science as a Creative Process
- BIO 85  Evolution
- BIO 145  Ecology and Evolution of Animal Behavior
- COMM 106  Communication Research Methods
- COMM 158  Censorship and Propaganda
- COMM 173E  Data Challenge Lab
- COMM 176  Advanced Digital Journalism Production
- COMM 177B  Big Local Journalism: a project-based class
- COMM 177P  Programming in Journalism
- COMM 177T  Building News Applications
- CS 145  Data Management and Data Systems
- CS 326  Topics in Advanced Robotic Manipulation
- ECON 102B  Applied Econometrics
- ECON 102C  Advanced Topics in Econometrics
- ECON 106  World Food Economy
- ECON 118  Development Economics
- ECON 125  Economic Development, Microfinance, and Social Networks
- ECON 144  Family and Society
- ECON 150  Economic Policy Analysis
- ECON 155  Environmental Economics and Policy
EDUC 260B  Advanced Statistical Methods for Observational Studies
LINGUIST 156  Language, Gender, & Sexuality
LINGUIST 157  Sociophonetics
LINGUIST 234  The Structure of Discourse: Theory and Applications
LINGUIST 250  Sociolinguistic Theory and Analysis
LINGUIST 258  Analysis of Variation
LINGUIST 278  Programming for Linguists
LINGUIST 285  Spoken Language Processing
MGTECON 634  Machine Learning and Causal Inference
MS&E 121  Introduction to Stochastic Modeling
MS&E 125  Introduction to Applied Statistics
MS&E 184  Future of Work: Issues in Organizational Learning and Design
MS&E 201  Dynamic Systems
MS&E 221  Stochastic Modeling
MS&E 223  Simulation
MS&E 230  Market Design for Engineers
MS&E 231  Introduction to Computational Social Science
MS&E 234  Data Privacy and Ethics
MS&E 243  Energy and Environmental Policy Analysis
MS&E 280  Organizational Behavior: Evidence in Action
MS&E 292  Health Policy Modeling
PHIL 2  Introduction to Moral Philosophy
PHIL 60  Introduction to Philosophy of Science
PHIL 170  Ethical Theory
PHIL 171  Justice
PHIL 171P  20th Century Political Theory: Liberalism and its Critics
PHIL 174B  Universal Basic Income: the philosophy behind the proposal
PHIL 175B  Philosophy of Public Policy
POLISCI 1  The Science of Politics
POLISCI 120Z  What’s Wrong with American Government? An Institutional Approach
POLISCI 150A  Data Science for Politics
POLISCI 150C  Causal Inference for Social Science
POLISCI 223A  Public Opinion and American Democracy
POLISCI 227C  Money in Politics
POLISCI 241A  Political Economy of Development
POLISCI 241S  Spatial Approaches to Social Science
PSYC 86Q  Psychology of Xenophobia
PSYCH 24N  Neuroforecasting
SOC 1  Introduction to Sociology
SOC 3  America: Unequal
SOC 10  Introduction to Computational Social Science
SOC 14N  Inequality in American Society
SOC 31N  Social Networks
SOC 114  Economic Sociology
SOC 118  Social Movements and Collective Action
SOC 124  Gender and Technology
SOC 130  Education and Society
SOC 133D  Globalization and Social Change
SOC 167VP  Justice + Poverty Innovation: Create new solutions for people to navigate housing, medical, & debt
SOC 168  Global Organizations: The Matrix of Change
SOC 179A  Crime and Punishment in America
STATS 101  Data Science 101
STATS 191  Introduction to Applied Statistics
STATS 200  Introduction to Statistical Inference
STATS 202  Data Mining and Analysis
STATS 203  Introduction to Regression Models and Analysis of Variance
STATS 211  Meta-research: Appraising Research Findings, Bias, and Meta-analysis
STTS 191W  Doing STTS: Introduction to Research
SYMSYS 201  Digital Technology, Society, and Democracy
Total Units  15-25

**Computer Music**

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

Symbolic Systems majors must complete the following requirements in addition to the Core requirements to fulfill the Concentration in Computer Music. All courses must be taken for 3 units or more.

**Computer-Generated Music I**

- **MUSIC 220A**  Fundamentals of Computer-Generated Sound  3-5
- **MUSIC 220B**  Compositional Algorithms, Psychoacoustics, and Computational Music  3-5

**Music and the Mind & Brain**

- **MUSIC 1A**  Music, Mind, and Human Behavior  3-5
- **MUSIC 251**  Psychophysics and Music Cognition  3-5
- **MUSIC 351A**  Seminar in Music Perception and Cognition  3-5
- **PSYCH 30**  Introduction to Perception  3-5
- **PSYCH 50**  Introduction to Cognitive Neuroscience  3-5

**Integrative Requirement**

Must be completed no earlier than the Junior Year

- i. Any of the Standard Options for all Concentrations specified under the Core Capstone requirement, or
- ii. A Concentration-Specific Integrative Course: A course that integrates the themes of the Concentration with the Core requirements. Select one of the following (with more options to be added as they are approved -- some options may be removed if they are included in the list of SYMSYS 195* project courses, in order to avoid redundancy with the Standard Options).

- **MUSIC 128**  Stanford Laptop Orchestra: Composition, Coding, and Performance  3-5
- **MUSIC 220C**  Research Seminar in Computer-Generated Music  3-5
- **MUSIC 250A**  Physical Interaction Design for Music  3-5
- **MUSIC 251**  Psychophysics and Music Cognition  3-5
- **MUSIC 253**  Symbolic Musical Information  3-5
- **MUSIC 254**  Computational Music Analysis  3-5
- **MUSIC 256A**  Music, Computing, Design: The Art of Design  3-5
- **MUSIC 257**  Neuroplasticity and Musical Gaming  3-5

Stanford Bulletin 2020-21
**Contingent Electives**  
3-5

If any of requirements 1-4 are fulfilled with courses taken for Core requirements, then additional approved Contingent Elective courses must be completed to total 5 courses beyond those that are taken for the Core. These electives can be one or more courses from any of the areas above, or which are approved for a Core requirement that the student has fulfilled with a different course, or any of the following:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</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 1A</td>
<td>Music, Mind, and Human Behavior</td>
</tr>
<tr>
<td>MUSIC 222</td>
<td>Sound in Space</td>
</tr>
</tbody>
</table>

Total Units: 
15-25

**Decision Making and Rationality (DMAR)**


Symbolic Systems majors completing the new Core requirements effective for 2020-2021 must complete the following requirements to qualify for a Concentration in Decision Making and Rationality. All courses must be taken for 3 units of more.

**Philosophical Inquiry**  
3-5

Select one of the following:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</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 133S</td>
<td>Heidegger and Mysticism</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 184B</td>
<td>Formal Epistemology</td>
</tr>
<tr>
<td>PHIL 187</td>
<td>Philosophy of Action</td>
</tr>
<tr>
<td>PHIL 359</td>
<td>Logic Spring Seminar</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>
<tr>
<td>POLISCI 230A</td>
<td>Classical Seminar: Origins of Political Thought</td>
</tr>
<tr>
<td>PSYCH 160</td>
<td>Seminar on Emotion</td>
</tr>
</tbody>
</table>

**Formal Decision Theories**  
3-5

Select one of the following:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECON 51</td>
<td>Economic Analysis II</td>
</tr>
<tr>
<td>ECON 136</td>
<td>Market Design</td>
</tr>
<tr>
<td>ECON 160</td>
<td>Game Theory and Economic Applications</td>
</tr>
<tr>
<td>ECON 180</td>
<td>Honors Game Theory</td>
</tr>
<tr>
<td>ECON 289</td>
<td>Advanced Topics in Game Theory and Information Economics</td>
</tr>
<tr>
<td>MS&amp;E 232</td>
<td>Introduction to Game Theory</td>
</tr>
<tr>
<td>MS&amp;E 232H</td>
<td>Introduction to Game Theory</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 359</td>
<td>Logic Spring Seminar</td>
</tr>
<tr>
<td>POLISCI 356A</td>
<td>Formal Theory I: Game Theory for Political Science</td>
</tr>
</tbody>
</table>

**Empirical Findings and Explanations**  
3-5

Select one of the following:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIO 150</td>
<td>Human Behavioral Biology</td>
</tr>
<tr>
<td>ECON 178</td>
<td>Behavioral Economics</td>
</tr>
<tr>
<td>ECON 179</td>
<td>Experimental Economics</td>
</tr>
<tr>
<td>ECON 279</td>
<td>Behavioral Economics II</td>
</tr>
<tr>
<td>EDUC 375A</td>
<td>Seminar on Organizational Theory</td>
</tr>
<tr>
<td>GS&amp;BGEN 646</td>
<td>Behavioral Economics and the Psychology of Decision Making</td>
</tr>
<tr>
<td>POLISCI 351B</td>
<td>Economic Analysis of Political Institutions</td>
</tr>
<tr>
<td>POLISCI 351C</td>
<td>Institutions and Bridge-Building in Political Economy</td>
</tr>
<tr>
<td>PSYCH 154</td>
<td>Judgment and Decision-Making</td>
</tr>
<tr>
<td>PSYCH 160</td>
<td>Seminar on Emotion</td>
</tr>
<tr>
<td>PSYCH 205</td>
<td>Foundations of Cognition</td>
</tr>
<tr>
<td>PSYCH 212</td>
<td>Classic and contemporary social psychology research</td>
</tr>
<tr>
<td>PSYCH 215</td>
<td>Mind, Culture, and Society</td>
</tr>
<tr>
<td>PSYCH 223</td>
<td>Social Norms</td>
</tr>
<tr>
<td>PSYCH 232</td>
<td>Brain and Decision</td>
</tr>
<tr>
<td>PSYCH 254</td>
<td>Affective Neuroscience</td>
</tr>
<tr>
<td>SOC 114</td>
<td>Economic Sociology</td>
</tr>
<tr>
<td>SOC 126</td>
<td>Introduction to Social Networks</td>
</tr>
<tr>
<td>SYMSYS 203</td>
<td>Cognitive Science Perspectives on Humanity and Well-Being</td>
</tr>
</tbody>
</table>

**Methods and Applications**  
3-5

A course on methods that can be used to study decision making and rationality, or ways to apply research in decision sciences. For example, one of the following:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIOMED 219</td>
<td>Mathematical Models and Medical Decisions</td>
</tr>
<tr>
<td>BIOMED 251</td>
<td>Outcomes Analysis</td>
</tr>
<tr>
<td>CEE 206</td>
<td>Decision Analysis for Civil and Environmental Engineers</td>
</tr>
<tr>
<td>COMM 106</td>
<td>Communication Research Methods</td>
</tr>
<tr>
<td>COMM 124</td>
<td>Truth, Trust, and Tech</td>
</tr>
<tr>
<td>CS 181</td>
<td>Computers, Ethics, and Public Policy</td>
</tr>
<tr>
<td>CS 182</td>
<td>Ethics, Public Policy, and Technological Change</td>
</tr>
<tr>
<td>CS 228</td>
<td>Probabilistic Graphical Models: Principles and Techniques</td>
</tr>
<tr>
<td>CS 234</td>
<td>Reinforcement Learning</td>
</tr>
<tr>
<td>CS 238</td>
<td>Decision Making under Uncertainty</td>
</tr>
<tr>
<td>CS 239</td>
<td>Advanced Topics in Sequential Decision Making</td>
</tr>
<tr>
<td>CS 261</td>
<td>Optimization and Algorithmic Paradigms</td>
</tr>
<tr>
<td>CS 325B</td>
<td>Data for Sustainable Development</td>
</tr>
<tr>
<td>ECON 50</td>
<td>Economic Analysis I</td>
</tr>
<tr>
<td>ECON 102B</td>
<td>Applied Econometrics</td>
</tr>
<tr>
<td>ECON 102C</td>
<td>Advanced Topics in Econometrics</td>
</tr>
<tr>
<td>ECON 135</td>
<td>Foundations of Finance</td>
</tr>
<tr>
<td>ECON 136</td>
<td>Market Design</td>
</tr>
<tr>
<td>ECON 137</td>
<td>Decision Modeling and Information</td>
</tr>
<tr>
<td>ECON 141</td>
<td>Public Finance and Fiscal Policy</td>
</tr>
<tr>
<td>ECON 150</td>
<td>Economic Policy Analysis</td>
</tr>
<tr>
<td>ECON 155</td>
<td>Environmental Economics and Policy</td>
</tr>
<tr>
<td>ECON 162</td>
<td>Games Developing Nations Play</td>
</tr>
</tbody>
</table>
ENGR 62  Introduction to Optimization
MS&E 121 Introduction to Stochastic Modeling
MS&E 135 Networks
MS&E 152 Introduction to Decision Analysis
MS&E 175 Innovation, Creativity, and Change
MS&E 180 Organizations: Theory and Management
MS&E 231 Introduction to Computational Social Science
MS&E 250A Engineering Risk Analysis
MS&E 250B Project Course in Engineering Risk Analysis
MS&E 252 Decision Analysis I: Foundations of Decision Analysis
MS&E 332 Security and Risk in Computer Networks
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 Probabilistics Networks
PHIL 49 Survey of Formal Methods
POLISCI 153 Thinking Strategically
PSYCH 10 Introduction to Statistical Methods: Precalculus
PSYCH 251 Experimental Methods
PSYCH 253 Advanced Statistical Modeling
STATS 191 Introduction to Applied Statistics
STATS 200 Introduction to Statistical Inference
STATS 211 Meta-research: Appraising Research Findings, Bias, and Meta-analysis
STATS 217 Introduction to Stochastic Processes I
STATS 218 Introduction to Stochastic Processes II
STATS 263 Design of Experiments
STATS 310A Theory of Probability I
STATS 310B Theory of Probability II
STATS 310C Theory of Probability III
SYMSYS 195B Design for Behavior Change
SYMSYS 195D Research in Digital Democracy
SYMSYS 201 Digital Technology, Society, and Democracy
URBANST 132 Concepts and Analytic Skills for the Social Sector

**Integrative Requirement** 3-5

Must be completed no earlier than the Junior Year.

i. Any of the Standard Options for all Concentrations specified under the Core Capstone requirement, or

ii. A Concentration-Specific Integrative Course: A course that integrates the themes of the Concentration with the Core requirements. Select one of the following (with more options to be added as they are approved -- some options may be removed if they are included in the list of SYMSYS 195* project courses, in order to avoid redundancy with the Standard Options).

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<th>Course</th>
<th>Title</th>
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<tbody>
<tr>
<td>CS 181</td>
<td>Computers, Ethics, and Public Policy</td>
</tr>
<tr>
<td>CS 182</td>
<td>Ethics, Public Policy, and Technological Change</td>
</tr>
<tr>
<td>CS 228</td>
<td>Probabilistic Graphical Models: Principles and Techniques</td>
</tr>
<tr>
<td>CS 234</td>
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<tr>
<td>CS 325B</td>
<td>Data for Sustainable Development</td>
</tr>
<tr>
<td>PHIL 184</td>
<td>Topics in Epistemology</td>
</tr>
<tr>
<td>PHIL 184B</td>
<td>Formal Epistemology</td>
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<tr>
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<td>Philosophy of Action</td>
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<tr>
<td>PSYCH 254</td>
<td>Affective Neuroscience</td>
</tr>
<tr>
<td>SYMSYS 201</td>
<td>Digital Technology, Society, and Democracy</td>
</tr>
<tr>
<td>SYMSYS 203</td>
<td>Cognitive Science Perspectives on Humanity and Well-Being</td>
</tr>
</tbody>
</table>

**Contingent Electives** 3-5

If any of requirements 1-4 are fulfilled with courses taken for Core requirements, then additional approved Contingent Elective courses must be completed to total 5 courses beyond those that are taken for the Core. These electives can be one or more courses from any of the areas above, or which are approved for a Core requirement that the student has fulfilled with a different course, or any of the following:

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<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECON 102D</td>
<td>Econometric Methods for Public Policy Analysis and Business Decision-Making</td>
</tr>
<tr>
<td>ECON 151</td>
<td>Tackling Big Questions Using Social Data Science</td>
</tr>
<tr>
<td>MS&amp;E 33N</td>
<td>How We Decide: Social Choice in the Age of Algorithms</td>
</tr>
</tbody>
</table>

Additional courses may be added here in the future.

**Total Units** 15-25

**Human-Centered Artificial Intelligence Concentration**

See also the Symbolic Systems website (https://symsys.stanford.edu/undergraduates/concentrations/human-centered-artificial-intelligence-hai-concentration/).

Symbolic Systems majors completing the new Core requirements effective for 2020-2021 must complete the following requirements to qualify for a Concentration in Human-Centered Artificial Intelligence. All courses must be taken for 3 units of more.

**Digital Technology Ethics and Policy** 3-5

Select one of the following:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS 181</td>
<td>Computers, Ethics, and Public Policy</td>
</tr>
<tr>
<td>CS 182</td>
<td>Ethics, Public Policy, and Technological Change</td>
</tr>
</tbody>
</table>

**Human Impact** 3-5

One course aimed at understanding how AI interacts with humans as well as with vital social structures and institutions. For example:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>AFRICAAM 200N</td>
<td>Funkentelechy: Technologies, Social Justice and Black Vernacular Cultures</td>
</tr>
<tr>
<td>ANTHRO 132D</td>
<td>Thinking Technology: Anthropological Perspectives</td>
</tr>
<tr>
<td>ANTHRO 134A</td>
<td>Whose Ghost in the Machine? Cultures, Politics and Morals of Artificial Intelligence</td>
</tr>
<tr>
<td>COMM 120W</td>
<td>The Rise of Digital Culture</td>
</tr>
<tr>
<td>COMM 124</td>
<td>Truth, Trust, and Tech</td>
</tr>
<tr>
<td>COMM 145</td>
<td>Personality and Digital Media</td>
</tr>
<tr>
<td>COMM 154</td>
<td>The Politics of Algorithms</td>
</tr>
<tr>
<td>COMM 172</td>
<td>Media Psychology</td>
</tr>
</tbody>
</table>
Augmenting Human Capabilities

One course aimed at developing new human-centered design methods and tools so that AI agents and applications are designed and created with the ability to communicate with, collaborate with, and augment people more effectively, and to make their work better and more enjoyable. For example:

- BIOMEDIN 220 Artificial Intelligence in Healthcare
- COMM 166 Virtual People
- COMM 177B Big Local Journalism: a project-based class
- COMM 326 Advanced Topics in Human Virtual Representation
- CS 147 Introduction to Human-Computer Interaction Design
- CS 152 Trust and Safety Engineering
- CS 184 Bridging Policy and Tech Through Design
- CS 247A Design for Artificial Intelligence
- CS 247B Design for Behavior Change
- CS 247I Design for Understanding
- CS 247S Service Design
- CS 278 Social Computing
- CS 325B Data for Sustainable Development
- CS 335 Fair, Accountable, and Transparent (FAccT) Deep Learning
- CS 372 Artificial Intelligence for Disease Diagnosis and Information Recommendations
- CS 448B Data Visualization
- ECON 136 Market Design
- EDUC 211 Beyond Bits and Atoms - Lab
- EDUC 236 Beyond Bits and Atoms: Designing Technological Tools
- EDUC 266 Educational Neuroscience
- EDUC 281 Technology for Learners
- EDUC 302 Behavior Design: Clubhouse for Helping People with Good Habits & Behavior Change
- GSBGEN 596 Designing AI to Cultivate Human Well-Being
- HUMBIO 135S Body Hacking: Applied Topics in Exercise Physiology
- HUMBIO 151R Biology, Health and Big Data
- MUSIC 220C Research Seminar in Computer-Generated Music
- PSYC 124 Brain Plasticity
- PSYC 223B Topics in Neurodiversity: Design Thinking Approaches
- PSYC 240 Designing for the 2 Billion: Leading Innovation in Mental Health
- PSYCH 24N Neuroforecasting
- PSYCH 273 Changing Mindsets and Contexts: How to Create Authentic, Lasting Improvement
- PSYCH 290 Natural Language Processing & Text-Based Machine Learning in the Social Sciences
- SOC 167VP Justice + Poverty Innovation: Create new solutions for people to navigate housing, medical, & debt
- SYMSYS 245 Cognition in Interaction Design

Intelligence

One course aimed at developing machine intelligence that understands human language, emotions, intentions, behaviors, and interactions at multiple scales. One of the following:

- CS 129 Applied Machine Learning
- CS 131 Computer Vision: Foundations and Applications
- CS 221 Artificial Intelligence: Foundations and Applications
- CS 223A Introduction to Robotics
- CS 224N Natural Language Processing with Deep Learning
- CS 229 Machine Learning
- CS 230 Deep Learning
- LINGUIST 188 Natural Language Understanding
- LINGUIST 285 Spoken Language Processing

Integrative Requirement

Must be completed no earlier than the Junior Year.

i. Any of the Standard Options for all Concentrations specified under the Core Capstone requirement, or

ii. A Concentration-Specific Integrative Course: A course that integrates the themes of the Concentration with the Core requirements. Select one of the following (with more options to be added as they are approved – some options may be removed if they are included in the list of SYMSYS 195* project courses, in order to avoid redundancy with the Standard Options).

- COMM 166 Virtual People
- COMM 172 Media Psychology
- CS 206 Exploring Computational Journalism
- CS 221 Artificial Intelligence: Principles and Techniques
- CS 223A Introduction to Robotics
- CS 229 Machine Learning
- CS 230 Deep Learning
- CS 238 Decision Making under Uncertainty
- CS 247I Design for Understanding
- CS 278 Social Computing
- CS 325B Data for Sustainable Development
- CS 335 Fair, Accountable, and Transparent (FAccT) Deep Learning
- CS 372 Artificial Intelligence for Disease Diagnosis and Information Recommendations
- CS 379C Computational Models of the Neocortex
- EDUC 234 Curiosity in Artificial Intelligence
### Human-Computer Interaction

See also the Symbolic Systems website (https://symsys.stanford.edu/undergraduates/concentrations/human-computer-interaction-hci-concentration/).

Symbolic Systems majors must complete the following requirements in addition to the Core requirements to fulfill the Concentration in Human-Computer Interaction. All courses must be taken for 3 units of more.

Students in this Concentration are urged to take CS 107 or CS 107E, either for the Post-CS 106B Computation Core requirement, or as a Contingent Elective, and prior to completing requirement 4 below.

<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>

#### Design Methods

Post-CS 147 courses teaching fundamentals of the human-centered design process, featuring a major project component (including any course in the CS 247 series). 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 247S</td>
<td>Service Design</td>
</tr>
</tbody>
</table>

#### HCI Theory

Courses teaching design, behavioral, and critical theories that underlie the design process. One of the following:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<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>CS 347</td>
<td>Human-Computer Interaction: Foundations and Frontiers</td>
</tr>
<tr>
<td>ME 341</td>
<td>Design Experiments</td>
</tr>
</tbody>
</table>

#### User Interface Implementation

An advanced course in programming for user interfaces. 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>
</tbody>
</table>

#### Integrative Requirement

Must be completed no earlier than the Junior Year.

i. Any of the Standard Options for all Concentrations specified under the Core Capstone requirement, or

ii. A Concentration-Specific Integrative Course: A course that integrates the themes of the Concentration with the Core requirements. Select one of the following (with more options to be added as they are approved – some options may be removed if they are included in the list of SYMSYS 195* project courses, in order to avoid redundancy with the Standard Options).

<table>
<thead>
<tr>
<th>Course</th>
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</thead>
<tbody>
<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 324</td>
<td>Language and Technology</td>
</tr>
<tr>
<td>COMM 326</td>
<td>Advanced Topics in Human Virtual Representation</td>
</tr>
<tr>
<td>CS 181</td>
<td>Computers, Ethics, and Public Policy</td>
</tr>
<tr>
<td>CS 182</td>
<td>Ethics, Public Policy, and Technological Change</td>
</tr>
</tbody>
</table>

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**Contingent Electives**

If requirements 1-4 are fulfilled partly from courses taken for Core requirements, then additional approved Elective courses must be completed to total 5 courses beyond those that are taken for the Core. These electives can be one or more courses from any of the areas above, or which are approved for a Core requirement that the student has fulfilled with a different course, or any of the following:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHIL 20N</td>
<td>Philosophy of Artificial Intelligence</td>
</tr>
<tr>
<td>STATS 191</td>
<td>Introduction to Applied Statistics</td>
</tr>
<tr>
<td>STATS 200</td>
<td>Introduction to Statistical Inference</td>
</tr>
</tbody>
</table>

**Total Units** 15-25
If any of requirements 1-4 are fulfilled with courses taken for Core requirements, then additional approved Contingent Elective courses must be completed to total 5 courses beyond those that are taken for the Core. These electives can be one or more courses from any of the areas above, or which are approved for a Core requirement that the student has fulfilled with a different course, or any of the following:

Any d.school course worth 3 or more units

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>ARTSTUDI 130</td>
<td>Interactive Art: Making it with Arduino</td>
</tr>
<tr>
<td>ARTSTUDI 142</td>
<td>Mixed-Media Drawing: Art &amp; Aesthetics of Social Media</td>
</tr>
<tr>
<td>ARTSTUDI 160</td>
<td>Intro to Digital / Physical Design</td>
</tr>
<tr>
<td>ARTSTUDI 168</td>
<td>Data as Material</td>
</tr>
<tr>
<td>ARTSTUDI 179</td>
<td>Digital Art I</td>
</tr>
<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 106</td>
<td>Communication Research Methods</td>
</tr>
<tr>
<td>COMM 124</td>
<td>Truth, Trust, and Tech</td>
</tr>
<tr>
<td>COMM 154</td>
<td>The Politics of Algorithms</td>
</tr>
<tr>
<td>COMM 230A</td>
<td>Digital Civil Society</td>
</tr>
<tr>
<td>COMM 230B</td>
<td>Digital Civil Society</td>
</tr>
<tr>
<td>COMM 230C</td>
<td>Digital Civil Society</td>
</tr>
<tr>
<td>COMM 314</td>
<td>Ethnographic Methods</td>
</tr>
<tr>
<td>CS 80Q</td>
<td>Race and Gender in Silicon Valley</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 101</td>
<td>Visual Thinking</td>
</tr>
<tr>
<td>ME 105</td>
<td>Designing for Impact</td>
</tr>
<tr>
<td>ME 115A</td>
<td>Introduction to Human Values in Design</td>
</tr>
<tr>
<td>ME 203</td>
<td>Design and Manufacturing</td>
</tr>
<tr>
<td>ME 210</td>
<td>Introduction to Mechatronics</td>
</tr>
<tr>
<td>ME 216A</td>
<td>Advanced Product Design: Needfinding</td>
</tr>
<tr>
<td>MED 147</td>
<td>Methods in Community Assessment, Evaluation, and Research</td>
</tr>
<tr>
<td>MED 275B</td>
<td>Biodesign Fundamentals</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>PHIL 71H</td>
<td>Introduction to Aesthetics</td>
</tr>
<tr>
<td>PSYCH 10</td>
<td>Introduction to Statistical Methods: Precalculus</td>
</tr>
<tr>
<td>SOC 167VP</td>
<td>Justice + Poverty Innovation: Create new solutions for people to navigate housing, medical, &amp; debt</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>
<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 203</td>
<td>Introduction to Regression Models and Analysis</td>
</tr>
<tr>
<td>STATS 263</td>
<td>Design of Experiments</td>
</tr>
</tbody>
</table>

**Total Units:** 15-25

### Learning

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

Symbolic Systems majors completing the new Core requirements effective for 2020-2021 must complete the following requirements to qualify for a Concentration in Learning. All courses must be taken for 3 units of more.

Students in the Learning Concentration must complete four courses from areas 1-3 below with at least one from each area, plus one course from area 4. If any of requirements 1-4 are fulfilled with courses taken for Core requirements, then additional approved Contingent Elective courses (see area 5) must be completed to total 5 courses beyond those that are taken for the Core.

### Computational Learning

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS 205L</td>
<td>Continuous Mathematical Methods with an Emphasis on Machine Learning</td>
</tr>
<tr>
<td>CS 221</td>
<td>Artificial Intelligence: Principles and Techniques</td>
</tr>
<tr>
<td>CS 224N</td>
<td>Natural Language Processing with Deep Learning</td>
</tr>
<tr>
<td>CS 228</td>
<td>Probabilistic Graphical Models: Principles and Techniques</td>
</tr>
<tr>
<td>CS 229</td>
<td>Machine Learning</td>
</tr>
<tr>
<td>CS 229M</td>
<td>Machine Learning Theory</td>
</tr>
<tr>
<td>CS 230</td>
<td>Deep Learning</td>
</tr>
<tr>
<td>CS 234</td>
<td>Reinforcement Learning</td>
</tr>
<tr>
<td>CS 236</td>
<td>Deep Generative Models</td>
</tr>
<tr>
<td>CS 325B</td>
<td>Data for Sustainable Development</td>
</tr>
<tr>
<td>EE 104</td>
<td>Introduction to Machine Learning</td>
</tr>
<tr>
<td>LINGUIST 180</td>
<td>From Languages to Information</td>
</tr>
<tr>
<td>MS&amp;E 234</td>
<td>Data Privacy and Ethics</td>
</tr>
<tr>
<td>PSYCH 204</td>
<td>Computation and Cognition: The Probabilistic Approach</td>
</tr>
<tr>
<td>PSYCH 209</td>
<td>Neural Network Models of Cognition</td>
</tr>
<tr>
<td>PSYCH 249</td>
<td>Large-Scale Neural Network Modeling for Neuroscience</td>
</tr>
<tr>
<td>STATS 101</td>
<td>Data Science 101</td>
</tr>
<tr>
<td>STATS 220</td>
<td>Machine Learning Methods for Neural Data Analysis</td>
</tr>
<tr>
<td>STATS 315A</td>
<td>Modern Applied Statistics: Learning</td>
</tr>
<tr>
<td>STATS 315B</td>
<td>Modern Applied Statistics: Data Mining</td>
</tr>
</tbody>
</table>
under the Core Capstone requirement, or

i. Any of the Standard Options for all Concentrations specified

Must be completed no earlier than the Junior Year.

Integrative Requirement

Must be completed no earlier than the Junior Year.

i. A Concentration-Specific Integrative Course: A course that integrates the themes of the Concentration with the Core requirements. Select one of the following (with more options to be added as they are approved – some options may be removed if they are included in the list of SYMSYS 195* project courses, in order to avoid redundancy with the Standard Options).

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>COMM 326</td>
<td>Advanced Topics in Human Virtual Representation</td>
</tr>
<tr>
<td>CS 181</td>
<td>Computers, Ethics, and Public Policy</td>
</tr>
<tr>
<td>CS 182</td>
<td>Ethics, Public Policy, and Technological Change</td>
</tr>
<tr>
<td>CS 221</td>
<td>Artificial Intelligence: Principles and Techniques</td>
</tr>
<tr>
<td>CS 228</td>
<td>Probabilistic Graphical Models: Principles and Techniques</td>
</tr>
<tr>
<td>CS 229</td>
<td>Machine Learning</td>
</tr>
<tr>
<td>CS 229M</td>
<td>Machine Learning Theory</td>
</tr>
<tr>
<td>CS 230</td>
<td>Deep Learning</td>
</tr>
<tr>
<td>CS 231A</td>
<td>Computer Vision: From 3D Reconstruction to Recognition</td>
</tr>
<tr>
<td>CS 234</td>
<td>Reinforcement Learning</td>
</tr>
<tr>
<td>CS 379C</td>
<td>Computational Models of the Neocortex</td>
</tr>
<tr>
<td>EDUC 251</td>
<td>Topics in Epistemology and Education</td>
</tr>
<tr>
<td>EDUC 261E</td>
<td>Curriculum and Instruction Elective in Data Science</td>
</tr>
<tr>
<td>EE 104</td>
<td>Introduction to Machine Learning</td>
</tr>
<tr>
<td>LINGUIST 180</td>
<td>From Languages to Information</td>
</tr>
<tr>
<td>PHIL 184B</td>
<td>Formal Epistemology</td>
</tr>
<tr>
<td>PSYCH 204</td>
<td>Computation and Cognition: The Probabilistic Approach</td>
</tr>
<tr>
<td>PSYCH 209</td>
<td>Neural Network Models of Cognition</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 265</td>
<td>Social Psychology and Social Change</td>
</tr>
<tr>
<td>PSYCH 266</td>
<td>Current Debates in Learning and Memory</td>
</tr>
<tr>
<td>EDUC 328</td>
<td>Topics in Learning and Technology: Core Mechanics for Learning</td>
</tr>
<tr>
<td>EDUC 333A</td>
<td>Understanding Learning Environments</td>
</tr>
<tr>
<td>EDUC 342</td>
<td>Child Development and New Technologies</td>
</tr>
<tr>
<td>EDUC 391</td>
<td>Engineering Education and Online Learning</td>
</tr>
<tr>
<td>EDUC 426</td>
<td>Unleashing Personal Potential: Behavioral Science and Design Thinking Applied to Self</td>
</tr>
<tr>
<td>MUSIC 257</td>
<td>Neuroplasticity and Musical Gaming</td>
</tr>
<tr>
<td>PSYCH 287</td>
<td>Brain Machine Interfaces: Science, Technology, and Application</td>
</tr>
<tr>
<td>SYMSYS 245</td>
<td>Cognition in Interaction Design</td>
</tr>
</tbody>
</table>

Contingent Electives

If any of requirements 1-3 are fulfilled with courses taken for Core requirements, then additional approved Contingent Elective courses must be completed to total 5 courses beyond those that are taken for the Core. These electives can be one or more courses from any of the areas above, or which are approved for a Core requirement that the student has fulfilled with a different course, or any of the following:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>PSYCH 10</td>
<td>Introduction to Statistical Methods: Precalculus</td>
</tr>
<tr>
<td>STATS 191</td>
<td>Introduction to Applied Statistics</td>
</tr>
<tr>
<td>STATS 200</td>
<td>Introduction to Statistical Inference</td>
</tr>
</tbody>
</table>

Additional courses may be added here in the future.

Total Units 15-25
Mathematical Foundations

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

Symbolic Systems majors completing the new Core requirements effective for 2020-2021 must complete the following requirements to qualify for a Concentration in Mathematical Foundations. All courses must be taken for 3 units of more.

**Multivariate Calculus and Linear Algebra** 10

One of the following two-course sequences (Note: The earlier courses in each series are included in the Core Preparations requirements. Students in this Concentration who began in the CME 100 series should switch to the MATH 52-MATH 53 series for the Concentration.)

- MATH 52 and MATH 53
- MATH 63CM and MATH 62CM
- MATH 62DM and MATH 63DM

**Matrix Theory and Applications** 3-5

Select one of the following:

- CS 205L : Continuous Mathematical Methods with an Emphasis on Machine Learning
- MATH 113 : Linear Algebra and Matrix Theory

**Applied Mathematics and Statistics** 3-5

Select one of the following:

- CME 107 : Introduction to Machine Learning
- CME 263 : Introduction to Linear Dynamical Systems
- CS 229M : Machine Learning Theory
- EE 263 : Introduction to Linear Dynamical Systems
- EE 276 : Information Theory
- MATH 108 : Introduction to Combinatorics and Its Applications
- MATH 110 : Applied Number Theory and Field Theory
- MATH 136 : Stochastic Processes
- MATH 158 : Basic Probability and Stochastic Processes with Engineering Applications
- MATH 159 : Discrete Probabilistic Methods
- MS&E 111 : Introduction to Optimization
- MS&E 111X : Introduction to Optimization (Accelerated)
- MS&E 121 : Introduction to Stochastic Modeling
- MS&E 201 : Dynamic Systems
- MS&E 213 : Introduction to Optimization Theory
- MS&E 221 : Stochastic Modeling
- PSYCH 253 : Advanced Statistical Modeling
- STATS 110 : Statistical Methods in Engineering and the Physical Sciences
- STATS 191 : Introduction to Applied Statistics
- STATS 200 : Introduction to Statistical Inference
- STATS 202 : Data Mining and Analysis
- STATS 216 : Introduction to Statistical Learning
- STATS 217 : Introduction to Stochastic Processes I

**Integrative Requirement** 3-5

Must be completed no earlier than the Junior Year.

i. Any of the Standard Options for all Concentrations specified under the Core Capstone requirement, or

ii. A Concentration-Specific Integrative Course: A course that integrates the themes of the Concentration with the Core requirements. Select one of the following (with more options to be added as they are approved – some options may be removed if they are included in the list of SYMSYS 195* project courses, in order to avoid redundancy with the Standard Options).

- CS 129 : Applied Machine Learning
- CS 151 : Logic Programming
- CS 154 : Introduction to the Theory of Computation
- CS 157 : Computational Logic
- CS 161 : Design and Analysis of Algorithms
- CS 163 : The Practice of Theory Research
- CS 205L : Continuous Mathematical Methods with an Emphasis on Machine Learning
- CS 224W : Machine Learning with Graphs
- CS 228 : Probabilistic Graphical Models: Principles and Techniques
- CS 229 : Machine Learning
- CS 229M : Machine Learning Theory
- CS 230 : Deep Learning
- CS 246 : Mining Massive Data Sets
- CS 254 : Computational Complexity
- CS 255 : Introduction to Cryptography
- CS 259Q : Quantum Computing
- CS 325B : Data for Sustainable Development
- CS 379C : Computational Models of the Neocortex
- ECON 160 : Game Theory and Economic Applications
- ECON 178 : Behavioral Economics
- ECON 180 : Honors Game Theory
- MATH 114 : Introduction to Scientific Computing
- MS&E 252 : Decision Analysis I: Foundations of Decision Analysis
- PHIL 151 : Metalogic
- PHIL 152 : Computability and Logic
- PHIL 154 : Modal Logic
- PHIL 155 : Topics in Mathematical Logic: Non-Classical Logic
- PHIL 162 : Philosophy of Mathematics
- PHIL 184B : Formal Epistemology
- PHIL 353 : Seminar on Philosophy of Logic and Mathematics
- PHIL 359 : Logic Spring Seminar
- PSYCH 154 : Judgment and Decision-Making
- PSYCH 204 : Computation and Cognition: The Probabilistic Approach
- PSYCH 204B : Computational Neuroimaging
- PSYCH 209 : Neural Network Models of Cognition
- PSYCH 232 : Brain and Decision
- PSYCH 242 : Theoretical Neuroscience
- PSYCH 249 : Large-Scale Neural Network Modeling for Neuroscience
- PSYCH 253 : Advanced Statistical Modeling
- SOC 154 : The Politics of Algorithms
- STATS 220 : Machine Learning Methods for Neural Data Analysis

Contingent Electives
If any of requirements 1-3 are fulfilled with courses taken for Core requirements, then additional approved Contingent Elective courses must be completed to total 5 courses beyond those that are taken for the Core. These electives can be one or more courses from any of the areas above, or which are approved for a Core requirement that the student has fulfilled with a different course, or any of the following:

- BIOMEDIN 219 Mathematical Models and Medical Decisions
- CS 250 Algebraic Error Correcting Codes
- CS 254B Computational Complexity II
- CS 263 Counting and Sampling
- EE 377 Information Theory and Statistics
- MATH 56 Proofs and Modern Mathematics
- MATH 107 Graph Theory
- MATH 115 Functions of a Real Variable
- MATH 120 Groups and Rings
- MATH 144 Introduction to Topology and Geometry
- MATH 152 Elementary Theory of Numbers
- MATH 171 Fundamental Concepts of Analysis
- PHIL 3N Randomness: Computational and Philosophical Approaches
- STATS 203 Introduction to Regression Models and Analysis of Variance
- STATS 206 Applied Multivariate Analysis
- STATS 218 Introduction to Stochastic Processes II
- STATS 221 Random Processes on Graphs and Lattices

**Total Units** 15-25

### Media and Communication Concentration

See also the Symbolic Systems website ([https://symsys.stanford.edu/undergraduateconcentrations/media-and-communication-mediaccom-concentration/](https://symsys.stanford.edu/undergraduateconcentrations/media-and-communication-mediaccom-concentration/)).

Symbolic Systems majors completing the new Core requirements effective for 2020-2021 must complete the following requirements to qualify for a Concentration in Media and Communication. All courses must be taken for 3 units of more

**Introduction**

- COMM 1 Introduction to Communication

**Statistical and Data Analysis Methods**

- ANTHRO 116 Data Analysis for Quantitative Research
- COMM 173E Data Challenge Lab
- CS 229 Machine Learning
- MS&E 125 Introduction to Applied Statistics
- MS&E 226 Fundamentals of Data Science: Prediction, Inference, Causality
- PSYCH 253 Advanced Statistical Modeling
- SOC 180B Introduction to Data Analysis
- STATS 60 Introduction to Statistical Methods: Precalculus
- STATS 101 Data Science 101
- STATS 110 Statistical Methods in Engineering and the Physical Sciences
- STATS 191 Introduction to Applied Statistics
- STATS 200 Introduction to Statistical Inference
- STATS 202 Data Mining and Analysis

**Research Methods** 3-5

A course on empirical and computational methods that are commonly used for research on media and communication. One of the following:

- COMM 106 Communication Research Methods
- CS 142 Web Applications
- CS 147 Introduction to Human-Computer Interaction Design
- CS 347 Human-Computer Interaction: Foundations and Frontiers
- CS 448B Data Visualization
- CSRE 433 Intersectional Qualitative Approaches
- EDUC 143 Introduction to Data Science
- EDUC 200B Introduction to Qualitative Research Methods
- EDUC 211 Beyond Bits and Atoms - Lab
- EDUC 236 Beyond Bits and Atoms: Designing Technological Tools
- HUMBIO 82A Qualitative Research Methodology
- ME 341 Design Experiments
- MS&E 135 Networks
- MS&E 231 Introduction to Computational Social Science
- MS&E 348 Optimization of Uncertainty and Applications in Finance
- PHIL 60 Introduction to Philosophy of Science
- POLISCI 150A Data Science for Politics
- POLISCI 150C Causal Inference for Social Science
- PSYCH 251 Experimental Methods
- SOC 10 Introduction to Computational Social Science
- SOC 180A Foundations of Social Research
- SOC 194 Computational Undergraduate Research
- SOC 369 Social Network Methods
- STATS 211 Meta-research: Appraising Research Findings, Bias, and Meta-analysis
- STS 191W Doing STS: Introduction to Research

**Effects, Ethics, and Policy** 3-5

A course on the effects of, and possible responses to, digital technology, media, and communication. For example, one of the following:

- AFRICAAM 200N Funkentelechy: Technologies, Social Justice and Black Vernacular Cultures
- ANTHRO 132D Thinking Technology: Anthropological Perspectives
- ANTHRO 134A Whose Ghost in the Machine? Cultures, Politics and Morals of Artificial Intelligence
- COMM 1B Media, Culture, and Society
- COMM 108 Media Processes and Effects
- COMM 120W The Rise of Digital Culture
- COMM 124 Truth, Trust, and Tech
- COMM 125 Perspectives on American Journalism
- COMM 135 Deliberative Democracy and its Critics
- COMM 145 Personality and Digital Media
- COMM 153B Free Speech, Democracy and the Internet
- COMM 154 The Politics of Algorithms
- COMM 162 Campaigns, Voting, Media, and Elections
- COMM 164 The Psychology of Communication About Politics in America
- COMM 166 Virtual People
In order to avoid redundancy with the Standard Options, students in the Natural Language Concentration must take four courses (see area 9) must be completed to total 5 courses beyond those that are taken for the Core. These electives can be one or more courses from any of the areas above, or which are approved for the Core requirement that the student has fulfilled with a different course, or any of the following:

ANTHRO 166A  Semiotics for Ethnography
EDUC 260B  Advanced Statistical Methods for Observational Studies
HUMBIO 82B  Advanced Data Analysis in Qualitative Research
LINGUIST 1  Introduction to Linguistics
LINGUIST 54N  Social Bias and Earwitness Memory
LINGUIST 127  Linguistic Meaning and Legal Interpretation
LINGUIST 234  The Structure of Discourse: Theory and Applications
LINGUIST 258  Analysis of Variation
LINGUIST 278  Programming for Linguists
LINGUIST 285  Spoken Language Processing
PSYCH 80  Introduction to Personality and Affective Science
PSYCH 155  Introduction to Comparative Studies in Race and Ethnicity
PSYCH 241  Psychometrics and automated experiment design
STATS 202  Data Mining and Analysis
STATS 203  Introduction to Regression Models and Analysis of Variance

Total Units 15-25

Natural Language

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

Symbolic Systems majors completing the new Core requirements effective for 2020-2021 must complete the following requirements to qualify for a Concentration in Natural Language. All courses must be taken for 3 units of more. Students in the Natural Language Concentration must take four courses from at least 3 of areas 1-7, plus a course from area 8. If any of requirements 1-7 are fulfilled with courses taken for Core requirements, then additional approved Contingent Elective courses must be completed to total 5 courses beyond those that are taken for the Core. These electives can be one or more courses from any of the areas above, or which are approved for a Core requirement that the student has fulfilled with a different course, or any of the following:

ANTHRO 166A  Semiotics for Ethnography
EDUC 260B  Advanced Statistical Methods for Observational Studies
HUMBIO 82B  Advanced Data Analysis in Qualitative Research
LINGUIST 1  Introduction to Linguistics
LINGUIST 54N  Social Bias and Earwitness Memory
LINGUIST 127  Linguistic Meaning and Legal Interpretation
LINGUIST 234  The Structure of Discourse: Theory and Applications
LINGUIST 258  Analysis of Variation
LINGUIST 278  Programming for Linguists
LINGUIST 285  Spoken Language Processing
PSYCH 80  Introduction to Personality and Affective Science
PSYCH 155  Introduction to Comparative Studies in Race and Ethnicity
PSYCH 241  Psychometrics and automated experiment design
STATS 202  Data Mining and Analysis
STATS 203  Introduction to Regression Models and Analysis of Variance

Total Units 15-25

Natural Language

See also the Symbolic Systems website (https://symsys.stanford.edu/undergraduatesconcentrations/natural-language-nl-concentration/).
<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS 221</td>
<td>Artificial Intelligence: Principles and Techniques</td>
<td>3-5</td>
</tr>
<tr>
<td>CS 229</td>
<td>Machine Learning</td>
<td>3-5</td>
</tr>
<tr>
<td>PHIL 154</td>
<td>Modal Logic</td>
<td>3-5</td>
</tr>
<tr>
<td>PSYCH 204</td>
<td>Computation and Cognition: The Probabilistic Approach</td>
<td>3-5</td>
</tr>
<tr>
<td>PSYCH 209</td>
<td>Neural Network Models of Cognition</td>
<td>3-5</td>
</tr>
<tr>
<td>PSYCH 251</td>
<td>Experimental Methods</td>
<td>3-5</td>
</tr>
<tr>
<td>PSYCH 254</td>
<td>Affective Neuroscience</td>
<td>3-5</td>
</tr>
<tr>
<td>PSYCH 140</td>
<td>Neural Network Models of Cognition</td>
<td>3-5</td>
</tr>
<tr>
<td>LINGUIST 110</td>
<td>Introduction to Phonology</td>
<td>3-5</td>
</tr>
<tr>
<td>LINGUIST 112</td>
<td>Seminar in Phonology: Stress, Tone, and Accent</td>
<td>3-5</td>
</tr>
<tr>
<td>LINGUIST 157</td>
<td>Sociophonetics</td>
<td>3-5</td>
</tr>
<tr>
<td>LINGUIST 207A</td>
<td>Advanced Phonetics</td>
<td>3-5</td>
</tr>
<tr>
<td>LINGUIST 210A</td>
<td>Phonology</td>
<td>3-5</td>
</tr>
<tr>
<td>LINGUIST 260A</td>
<td>Historical Morphology and Phonology</td>
<td>3-5</td>
</tr>
<tr>
<td>LINGUIST 121A</td>
<td>The Syntax of English</td>
<td>3-5</td>
</tr>
<tr>
<td>LINGUIST 121B</td>
<td>Crosslinguistic Syntax</td>
<td>3-5</td>
</tr>
<tr>
<td>LINGUIST 217</td>
<td>Morphosyntax</td>
<td>3-5</td>
</tr>
<tr>
<td>LINGUIST 222A</td>
<td>Foundations of Syntactic Theory I</td>
<td>3-5</td>
</tr>
<tr>
<td>LINGUIST 225D</td>
<td>Seminar in Syntax: Advanced Topics</td>
<td>3-5</td>
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<tr>
<td>LINGUIST 260B</td>
<td>Historical Morphosyntax</td>
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<tr>
<td>LINGUIST 130A</td>
<td>Introduction to Semantics and Pragmatics</td>
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<tr>
<td>LINGUIST 130B</td>
<td>Introduction to Lexical Semantics</td>
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<td>LINGUIST 132</td>
<td>Lexical Semantic Typology</td>
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<td>LINGUIST 230B</td>
<td>Advanced Semantics</td>
<td>3-5</td>
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<tr>
<td>LINGUIST 230C</td>
<td>Advanced Topics in Semantics &amp; Pragmatics</td>
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<tr>
<td>LINGUIST 232A</td>
<td>Lexical Semantics</td>
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<tr>
<td>LINGUIST 236</td>
<td>Seminar in Semantics: Conditionals</td>
<td>3-5</td>
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<tr>
<td>PHIL 137</td>
<td>Wittgenstein</td>
<td>3-5</td>
</tr>
<tr>
<td>PHIL 181</td>
<td>Philosophy of Language</td>
<td>3-5</td>
</tr>
<tr>
<td>PHIL 182A</td>
<td>Naturalizing Representation</td>
<td>3-5</td>
</tr>
<tr>
<td>PHIL 194D</td>
<td>Capstone Seminar: Artificial Intelligence</td>
<td>3-5</td>
</tr>
<tr>
<td>PHIL 348</td>
<td>Evolution of Signalling</td>
<td>3-5</td>
</tr>
<tr>
<td>PHIL 356C</td>
<td>Logic and Artificial Intelligence</td>
<td>3-5</td>
</tr>
<tr>
<td>PHIL 357</td>
<td>Research Seminar on Logic and Cognition</td>
<td>3-5</td>
</tr>
<tr>
<td>PHIL 359</td>
<td>Logic Spring Seminar</td>
<td>3-5</td>
</tr>
<tr>
<td>PHIL 385D</td>
<td>Advanced Topics in Philosophy of Language</td>
<td>3-5</td>
</tr>
<tr>
<td>PSYCH 204</td>
<td>Computation and Cognition: The Probabilistic Approach</td>
<td>3-5</td>
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<tr>
<td>PSYCH 209</td>
<td>Neural Network Models of Cognition</td>
<td>3-5</td>
</tr>
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<td>LINGUIST 65</td>
<td>African American Vernacular English</td>
<td>3-5</td>
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<tr>
<td>LINGUIST 116A</td>
<td>Introduction to Word-Formation</td>
<td>3-5</td>
</tr>
<tr>
<td>LINGUIST 150</td>
<td>Language and Society</td>
<td>3-5</td>
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<tr>
<td>LINGUIST 150E</td>
<td>Who Speaks Good English</td>
<td>3-5</td>
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<tr>
<td>LINGUIST 152</td>
<td>Sociolinguistics and Pidgin Creole Studies</td>
<td>3-5</td>
</tr>
<tr>
<td>LINGUIST 156</td>
<td>Language, Gender, &amp; Sexuality</td>
<td>3-5</td>
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<tr>
<td>LINGUIST 157</td>
<td>Sociophonetics</td>
<td>3-5</td>
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<td>LINGUIST 168</td>
<td>Introduction to Linguistic Typology</td>
<td>3-5</td>
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<td>COMM 324</td>
<td>Language and Technology</td>
<td>3-5</td>
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<td>CS 221</td>
<td>Artificial Intelligence: Principles and Techniques</td>
<td>3-5</td>
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<tr>
<td>CS 276</td>
<td>Information Retrieval and Web Search</td>
<td>3-5</td>
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<tr>
<td>LINGUIST 180</td>
<td>From Languages to Information</td>
<td>3-5</td>
</tr>
<tr>
<td>PHIL 137</td>
<td>Wittgenstein</td>
<td>3-5</td>
</tr>
<tr>
<td>PHIL 181</td>
<td>Philosophy of Language</td>
<td>3-5</td>
</tr>
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<td>PHIL 182A</td>
<td>Naturalizing Representation</td>
<td>3-5</td>
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<td>Evolution of Signalling</td>
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</tr>
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<td>PHIL 356C</td>
<td>Logic and Artificial Intelligence</td>
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<td>Computation and Cognition: The Probabilistic Approach</td>
<td>3-5</td>
</tr>
<tr>
<td>PSYCH 209</td>
<td>Neural Network Models of Cognition</td>
<td>3-5</td>
</tr>
<tr>
<td>PSYCH 10</td>
<td>Introduction to Statistical Methods: Precalculus</td>
<td>3-5</td>
</tr>
<tr>
<td>STATS 191</td>
<td>Introduction to Applied Statistics</td>
<td>3-5</td>
</tr>
<tr>
<td>STATS 200</td>
<td>Introduction to Statistical Inference</td>
<td>3-5</td>
</tr>
<tr>
<td>SYMSYS 207</td>
<td>Conceptual Issues in Cognitive Science</td>
<td>3-5</td>
</tr>
</tbody>
</table>

**Total Units: 15-25**

**Neurosciences**

See also the Symbolic Systems website (https://symsys.stanford.edu/undergraduatesconcentrations/neurosciences-neuro-concentration/).
Symbolic Systems majors completing the new Core requirements effective for 2020-2021 must complete the following requirements to qualify for a Concentration in Neurosciences. All courses must be taken for 3 units or more.

Students in the Neurosciences Concentration must take a total of five courses. At least two of the five courses must be from the first two areas, and at least one must come from area 7. If any of the courses listed under areas 1-6 are taken for Core requirements, then additional approved Contingent Elective courses (see area 8) must be completed to total 5 courses beyond those that are taken for the Core. Area 9 (Recommended Add-ons) consists of one- and two-unit courses that supplement areas 1-8. Add-on courses do not count toward the 5-course requirement for the Concentration.

### Basic Neuroscience 3-5
- BIO 84 Physiology
- BIO 86 Cell Biology
- 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
- PSYC 121 Ion Transport and Intracellular Messengers
- PSYC 141 Cognitive Development
- PSYC 205 Foundations of Cognition

Note: NBIO 206 is a 6-unit course, which counts as two concentration courses, from areas 1 and 2.

### Systems Neuroscience 3-5
- BIO 158 Developmental Neurobiology
- BIO 222 Exploring Neural Circuits
- EDUC 266 Educational Neuroscience
- PSYC 124 Brain Plasticity
- PSYC 30 Introduction to Perception
- PSYC 45 Introduction to Learning and Memory
- PSYC 50 Introduction to Cognitive Neuroscience
- PSYC 162 Brain Networks
- PSYC 169 Advanced Seminar on Memory
- PSYC 232 Brain and Decision
- PSYC 254 Affective Neuroscience
- PSYC 266 Current Debates in Learning and Memory

### Computational Approaches 3-5
- BIOE 101 Systems Biology
- BIOE 300B Quantitative Physiology
- CS 223A Introduction to Robotics
- CS 229 Machine Learning
- CS 379C Computational Models of the Neocortex
- EE 124 Introduction to Neuroelectrical Engineering
- MATSCI 384 Materials Advances for Neurotechnology: Materials Meet the Mind
- MUSIC 257 Neuroplasticity and Musical Gaming
- PSYC 164 Brain decoding
- PSYC 204 Computation and Cognition: The Probabilistic Approach
- PSYC 204A Human Neuroimaging Methods
- PSYC 204B Computational Neuroimaging
- PSYC 209 Neural Network Models of Cognition
- PSYC 249 Large-Scale Neural Network Modeling for Neuroscience
- PSYC 287 Brain Machine Interfaces: Science, Technology, and Application
- STATS 220 Machine Learning Methods for Neural Data Analysis

### Biological and Computational Approaches to Vision 3-5
- CS 131 Computer Vision: Foundations and Applications
- CS 231A Computer Vision: From 3D Reconstruction to Recognition
- CS 231N Convolutional Neural Networks for Visual Recognition
- PSYC 30 Introduction to Perception
- PSYC 221 Image Systems Engineering
- PSYC 250 High-level Vision: From Neurons to Deep Neural Networks

### Philosophical and Theoretical Approaches 3-5
- 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
- PHIL 368A Topics in Neuroscience
- PSYC 242 Theoretical Neuroscience
- SYMSYS 207 Conceptual Issues in Cognitive Science

### Methodological Foundations 3-5
- BIOE 291 Principles and Practice of Optogenetics for Optical Control of Biological Tissues
- CS 205L Continuous Mathematical Methods with an Emphasis on Machine Learning
- CS 448B Data Visualization
- 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
- PSYC 10 Introduction to Statistical Methods: Precalculus
- PSYC 187 Research Methods in Cognition & Development
- PSYC 204A Human Neuroimaging Methods
- PSYC 251 Experimental Methods
- PSYC 252 Statistical Methods for Behavioral and Social Sciences
- PSYC 253 Advanced Statistical Modeling
- STATS 110 Statistical Methods in Engineering and the Physical Sciences
- STATS 141 Biostatistics
- STATS 191 Introduction to Applied Statistics
- STATS 200 Introduction to Statistical Inference

### Integrative Requirement 3-5
Must be completed no earlier than the Junior Year.

i. Any of the Standard Options for all Concentrations specified under the Core Capstone requirement, or
ii. A Concentration-Specific Integrative Course: A course that integrates the themes of the Concentration with the Core requirements. Select one of the following (with more options to be added as they are approved -- some options may be removed if they are included in the list of SYMSYS 195* project courses, in order to avoid redundancy with the Standard Options).

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS 131</td>
<td>Computer Vision: Foundations and Applications</td>
</tr>
<tr>
<td>CS 221</td>
<td>Artificial intelligence: Principles and Techniques</td>
</tr>
<tr>
<td>CS 228</td>
<td>Probabilistic Graphical Models: Principles and Techniques</td>
</tr>
<tr>
<td>CS 229</td>
<td>Machine Learning</td>
</tr>
<tr>
<td>CS 230</td>
<td>Deep Learning</td>
</tr>
<tr>
<td>CS 231A</td>
<td>Computer Vision: From 3D Reconstruction to Recognition</td>
</tr>
<tr>
<td>CS 234</td>
<td>Reinforcement Learning</td>
</tr>
<tr>
<td>CS 379C</td>
<td>Computational Models of the Neocortex</td>
</tr>
<tr>
<td>PHIL 167D</td>
<td>Philosophy of Neuroscience</td>
</tr>
<tr>
<td>PHIL 357</td>
<td>Research Seminar on Logic and Cognition</td>
</tr>
<tr>
<td>PHIL 360</td>
<td>Grad Seminar: Philosophy of Neuroscience</td>
</tr>
<tr>
<td>PHIL 368A</td>
<td>Topics in Neuroscience</td>
</tr>
<tr>
<td>PSYC 223B</td>
<td>Topics in Neurodiversity: Design Thinking Approaches</td>
</tr>
<tr>
<td>PSYCH 121</td>
<td>Ion Transport and Intracellular Messengers</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 169</td>
<td>Advanced Seminar on Memory</td>
</tr>
<tr>
<td>PSYCH 202</td>
<td>Cognitive Neuroscience</td>
</tr>
<tr>
<td>PSYCH 204</td>
<td>Computation and Cognition: The Probabilistic Approach</td>
</tr>
<tr>
<td>PSYCH 204A</td>
<td>Human Neuroimaging Methods</td>
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<td>PSYCH 204B</td>
<td>Computational Neuroimaging</td>
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<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 242</td>
<td>Theoretical Neuroscience</td>
</tr>
<tr>
<td>PSYCH 247</td>
<td>Topics in Natural and Artificial Intelligence</td>
</tr>
<tr>
<td>PSYCH 249</td>
<td>Large-Scale Neural Network Modeling for Neuroscience</td>
</tr>
<tr>
<td>PSYCH 254</td>
<td>Affective Neuroscience</td>
</tr>
<tr>
<td>STATS 220</td>
<td>Machine Learning Methods for Neural Data Analysis</td>
</tr>
<tr>
<td>SYMSYS 202</td>
<td>Theories of Consciousness</td>
</tr>
<tr>
<td>SYMSYS 205</td>
<td>The Philosophy and Science of Perception</td>
</tr>
<tr>
<td>SYMSYS 207</td>
<td>Conceptual Issues in Cognitive Science</td>
</tr>
<tr>
<td>SYMSYS 245</td>
<td>Cognition in Interaction Design</td>
</tr>
</tbody>
</table>

**Contingent Electives**

If any of the courses listed under areas 1-6 are taken for Core requirements, then additional approved Contingent Elective courses must be completed to total 5 courses beyond those that are taken for the Core. These electives can be one or more courses from any of the areas above, or which are approved for a Core requirement that the student has fulfilled with a different course, or any of the following:

Additional courses may be added here in the future.

**Recommended Add-ons**

One- and two-unit courses that supplement the offerings above. These courses are recommended, but do not count toward the 5-course requirement for the Concentration:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>NSUR 239</td>
<td>NeuroTech Training Seminar</td>
</tr>
</tbody>
</table>

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**NSUR 249 Experimental Immersion in Neuroscience**

**Total Units:**

**Philosophical Foundations**

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

Symbolic Systems majors completing the new Core requirements effective for 2020-2021 must complete the following requirements to qualify for a Concentration in Philosophical Foundations. All courses must be taken for 3 units of more.

**Philosophy of Mind and Language**

One course from the PHIL 180-series:

| PHIL 180 | Metaphysics |
| PHIL 181 | Philosophy of Language |
| PHIL 182A| Naturalizing Representation |
| PHIL 182H| Truth |
| PHIL 183 | Self-knowledge and Metacognition |
| PHIL 184 | Topics in Epistemology |
| PHIL 184B| Formal Epistemology |
| PHIL 184M| Topics in the Theory of Justification |
| PHIL 185 | Special Topics in Epistemology: Testimony in science and everyday life |
| PHIL 185W| Metaontology |
| PHIL 186 | Philosophy of Mind |
| PHIL 187 | Philosophy of Action |
| PHIL 188W| Paradoxes |
| PHIL 189G| Fine-Tuning Arguments for God’s Existence |

**Ethics, Historical, and Political Philosophy**

Courses must be numbered 100 or above.

Select one of the following:

| PHIL 102 | Modern Philosophy, Descartes to Kant |
| PHIL 107B| Plato’s Later Metaphysics and Epistemology |
| PHIL 172 | History of Modern Moral Philosophy |
| PHIL 173B| Metaethics |
| PHIL 175 | Philosophy of Law |
| PHIL 194P| Capstone Seminar: The Meaning of Life |

**Logic**

Select one of the following:

| CS 154 | Introduction to the Theory of Computation |
| PHIL 152| Computability and Logic |
| PHIL 154 | Modal Logic |
| PHIL 359| Logic Spring Seminar |

**Philosophy of Science**

Select one of the following:

| PHIL 20N | Philosophy of Artificial Intelligence |
| PHIL 162 | Philosophy of Mathematics |
| PHIL 165 | Philosophy of Physics: Space and Time |
| PHIL 167D| Philosophy of Neuroscience |
| PHIL 169 | Evolution of the Social Contract |
| SYMSYS 207 | Conceptual Issues in Cognitive Science |

**Integrative Requirement**

Must be completed no earlier than the Junior Year.

- i. Any of the Standard Options for all Concentrations specified under the Core Capstone requirement, or
ii. A Concentration-Specific Integrative Course: A course that integrates the themes of the Concentration with the Core requirements. Select one of the following (with more options to be added as they are approved -- some options may be removed if they are included in the list of SYMSYS 195* project courses, in order to avoid redundancy with the Standard Options).

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
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</thead>
<tbody>
<tr>
<td>CS 181</td>
<td>Computers, Ethics, and Public Policy</td>
</tr>
<tr>
<td>CS 182</td>
<td>Ethics, Public Policy, and Technological Change</td>
</tr>
<tr>
<td>NBIO 101</td>
<td>Social and Ethical Issues in the Neurosciences</td>
</tr>
<tr>
<td>PHIL 134A</td>
<td>Phenomenology: Animals</td>
</tr>
<tr>
<td>PHIL 162</td>
<td>Philosophy of Mathematics</td>
</tr>
<tr>
<td>PHIL 167D</td>
<td>Philosophy of Neuroscience</td>
</tr>
<tr>
<td>PHIL 169</td>
<td>Evolution of the Social Contract</td>
</tr>
<tr>
<td>PHIL 184B</td>
<td>Formal Epistemology</td>
</tr>
<tr>
<td>PHIL 194D</td>
<td>Capstone Seminar: Artificial Intelligence</td>
</tr>
<tr>
<td>PHIL 194Y</td>
<td>Capstone seminar: Common Sense Philosophy</td>
</tr>
<tr>
<td>PHIL 350</td>
<td>What makes a good explanation? Psychological and philosophical perspectives</td>
</tr>
<tr>
<td>PHIL 359</td>
<td>Logic Spring Seminar</td>
</tr>
<tr>
<td>PHIL 360</td>
<td>Grad Seminar: Philosophy of Neuroscience</td>
</tr>
<tr>
<td>PHIL 368A</td>
<td>Topics in Neuroscience</td>
</tr>
<tr>
<td>PHIL 385B</td>
<td>Topics in Metaphysics and Epistemology: Situations and Attitudes</td>
</tr>
<tr>
<td>PSYCH 160</td>
<td>Seminar on Emotion</td>
</tr>
<tr>
<td>SYMSYS 202</td>
<td>Theories of Consciousness</td>
</tr>
<tr>
<td>SYMSYS 205</td>
<td>The Philosophy and Science of Perception</td>
</tr>
<tr>
<td>SYMSYS 207</td>
<td>Conceptual Issues in Cognitive Science</td>
</tr>
</tbody>
</table>

Contingent Electives

If any of requirements 1-4 are fulfilled with courses taken for Core requirements, then additional approved Contingent Elective courses must be completed to total 5 courses beyond those that are taken for the Core. These electives can be one or more courses from any of the areas above, or which are approved for a Core requirement that the student has fulfilled with a different course, or any of the following:

- Additional courses may be added here in the future.

Total Units 15-25

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) 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.

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>Course Code</th>
<th>Course Title</th>
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<tbody>
<tr>
<td>a. Cognition</td>
<td>Minds and Machines (formerly SYMSYS 100)</td>
</tr>
<tr>
<td>PSYCH 45</td>
<td>Introduction to Learning and Memory</td>
</tr>
<tr>
<td>PSYCH 50</td>
<td>Introduction to Cognitive Neuroscience</td>
</tr>
</tbody>
</table>

Units
### Option 2

#### Introduction

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

**Total Units:** 19

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**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://symsys.stanford.edu/graduatesms-admissions/coterm-admissions/) 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/6567.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 “Coterm Bachelor’s and Master’s Degrees” section of this bulletin. University requirements for the master’s degree are described in the “Graduate Degrees” 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 (https://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
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 36 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://symsys.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
   • NBIO 206 The Nervous System
   • NBIO 258
   • 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
• 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
• PHIL 287 Philosophy of Action
• PHIL 327 Scientific Philosophy: From Kant to Kuhn and Beyond
• PHIL 348 Evolution of Signalling
• PHIL 359 Logic Spring Seminar
• PHIL 377


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/registr/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 and Academic Continuity (http://exploredegrees.stanford.edu/covid-19-policy-changes/#tempdepttemplatetabtext)" 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.

Undergraduate Degree Requirements
Grading

The Symbolic Systems Program counts all courses taken in academic year 2020-21 with a grade of 'CR' (credit) or 'S' (satisfactory) towards satisfaction of undergraduate degree requirements that otherwise require a letter grade. The program also continues to count courses passed with a ‘C’-grade letter grade or above towards the satisfaction of all core requirements, and with a ‘D’- or above towards the satisfaction of concentration requirements.

Other Policies

The deadline for juniors to declare a concentration advisor has been extended to Winter Quarter. A registration hold will be placed on juniors who have not declared a concentration advisor before registration opens for Spring Quarter 2020-21.

Graduate Degree Requirements
Grading

The master’s program in Symbolic Systems counts all courses taken in academic year 2020-21 with a grade of 'D-', 'CR' (credit) or 'S' (satisfactory) towards satisfaction of graduate degree requirements that otherwise require a letter grade, subject to a graduate GPA requirement of 3.0 or above in the courses that constitute a master’s student’s 45 required units.

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

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)
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. If you have any questions about the course, please email symsys1staff@gmail.com.
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 2S. 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 survey 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 8. The Logic Group. 1-2 Unit.
If all dogs bark and Fido is a dog, it follows that Fido barks. If Clark Kent owns a car, it follows that Superman owns a car, since Clark Kent is Superman. Yet you might wonder why these statements follow from the said assumptions. Can this perhaps be explained in terms of the statements’ meanings or their grammatical form? Will the explanation be the same in both cases, or do statements follow from assumptions for a variety of different reasons? Are there laws or principles which conclusively prove the statements from the assumptions? Can these laws be doubted, or are they self-evident? The Logic Group will tackle these and similar questions. You will gain a solid understanding of both propositional and predicate logic, including a deductive proof system. You will familiarise yourself with the central concepts of formal reasoning, including syntax and semantics, truth and interpretation, validity and soundness, and the concept of logical consequence. Although formal and technical, the course is accessible to all students, and all may benefit. Studying logic will improve your analytic and critical thinking skills and help you develop a more rigorous and precise writing style. Only open to students residing at Stanford House in Oxford (UK). Same as: Oxford

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 statistical models to learn from human-generated data and find patterns or make predictions. We will explore different algorithms that create a wide variety of models, each with their own pros and cons. Through R programming exercises integrated across the course, we will apply these models to many different kinds of data sourced from urban development, education, business, etc. and analyze our findings. Based on individual interest, students will choose to investigate a specific research question using domain-specific data as part of a quarter-long project. Lastly, 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 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.n (Not open to freshmen.) Same as: PHIL 167D, PHIL 267D

SYMSYS 168A. A.I.-Activism-Art. 3-5 Units.
Lecture/studio course exploring arts and humanities scholarship and practice engaging with, and generated by, emerging emerging and exponential technologies. Our course will explore intersections of art and artificial intelligence with an emphasis on social impact and racial justice. Open to all undergraduates.
Same as: ARTHIST 168A, CSRE 106A, ENGLISH 106A

SYMSYS 190. Senior Honors Tutorial. 1-5 Unit.
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 SymSys curriculum to a substantial work experience. Must be accompanied by an approved internship or service project totaling 64 hours or more of total work time, which may be completed prior to, during, or following the course. A summary of the planned or completed internship/project is due during Week 2. Final passage in the course requires the Internship/Project summary, along with either (a) a letter certifying completed employment (for previous internships), (b) a letter of offer (for future employment during specified dates), or (c) a letter from the Haas Center for Public Service or a community organization certifying a public service project meeting the above criteria.

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 HAI? 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. Prerequisite: 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 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 195M. Measuring Learning in the Brain. 3 Units.
Everything we learn - be it a historical fact, the meaning of a new word, or a skill like reading, math, programming or playing the piano - depends on brain plasticity. The human brain’s incredible capacity for learning is served by a variety of learning mechanisms that all result in changes in brain structure and function over different time scales. The goal of this course is to (a) provide an overview of different learning systems in the brain, (b) introduce methodologies and experiments that have led to new discoveries linking human brain plasticity and learning, (c) design an experiment, collect neuroimaging data, and measure the neurobiological underpinnings of learning in your own brain with MRI. The first section of the course will involve a series of lectures and discussions on the foundations of plasticity and learning with particular attention to experimental methods used in human neuroimaging studies. The second part of the course will involve workshops on designing and implementing experiments in MATLAB/Psychedtoolbox or Python/PsychoPy. During this part of the course students will design, present and implement their own experiments as group projects. Finally, students will learn how to collect and analyze MRI data by being participants in their own fMRI experiments or analyzing publicly available datasets. Requirements: This class is designed for students who are interested in gaining hands-on experience with measuring the neurobiological underpinnings of learning. Student projects will involve designing experiments, collecting and analyzing data. So some experience with MATLAB/Python or an equivalent programming language is required. Some background in neuroscience (at least 1 course) is also required as we will assume basic knowledge. Same as: EDUC 464, NEPR 464, PSYCH 279

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. If you have any questions about the course, please email symsys1.staff@gmail.com.
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?, and 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 what 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 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.

SYMSYS 289. 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.

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. Prerequisite: 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 to teach a course in Symbolic Systems. Sign up with the instructor 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.