SYMBOLIC SYSTEMS

Courses offered by the Symbolic Systems Program are listed under the subject code SYMSYS on the (http://explorecourses.stanford.edu/CourseSearch/search/?view=catalog&catalog=&page=0&q=SYMSYS&filter-catalognumber-SYMSYS=on) Stanford Bulletin's (http://explorecourses.stanford.edu/CourseSearch/search/?view=catalog&catalog=&page=0&q=SYMSYS&filter-catalognumber-SYMSYS=on) ExploreCourses web site (http://explorecourses.stanford.edu/CourseSearch/search/?view=catalog&catalog=&page=0&q=SYMSYS&filter-catalognumber-SYMSYS=on).

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 an 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://studyinthestates.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).

Students declaring the major prior to 2020-21 should consult previous Stanford Bulletins (http://exploredegrees.stanford.edu/archive/#text) for degree requirements. Such students should consult the student services office if they want to change to the new requirements.

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/undergraduatesundergrad-advisingadvising-fellows/advising-office-hours/) on the Symsys website for possible interview times.

Advising

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

- Declared majors have until the Autumn Quarter of their junior year to select a concentration advisor. Juniors declaring the major must have a concentration advisor confirmed at the time of declaration.
- 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

		Units
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 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	4
PHIL 167D	Philosophy of Neuroscience	4
PHIL 172	History of Modern Moral Philosophy	4
PHIL 173B	Metaethics	4
PHIL 175	Philosophy of Law	4
PHIL 180	Metaphysics	4
PHIL 180A		
PHIL 181	Philosophy of Language	4
PHIL 182		
PHIL 182A	Naturalizing Representation	4
PHIL 182H	Truth	4
PHIL 184	Topics in Epistemology	4
PHIL 186	Philosophy of Mind	4
PHIL 187	Philosophy of Action	4
PHIL 189G	Fine-Tuning Arguments for God's Existence	4
SYMSYS 205	The Philosophy and Science of Perception	3
SYMSYS 207	Conceptual Issues in Cognitive Science	3

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:

CS 157	Computational Logic	3
PHIL 150	Mathematical Logic	4
PHIL 151	Metalogic (Prerequisite: PHIL 150 or instructor permission)	4

ii. Theory of Computation. One of the following:

CS 103	Mathematical Foundations of Computing (Corequisite: CS 106B or X)	3-5
CS 154	Introduction to the Theory of Computation (Prerequisite: CS 103 or significant proof-writing experience.)	3-4

iii. Probability Theory and Statistics

A course that covers the theory of probability and is grounded in multivariable calculus. One of the following:

CME 106	Introduction to Probability and Statistics for Engineers	4
CS 109	Introduction to Probability for Computer Scientists	3-5
EE 178	Probabilistic Systems Analysis	3-4
MATH 151	Introduction to Probability Theory	3
MATH 63DM	Modern Mathematics: Discrete Methods	5
MS&E 120	Introduction to Probability	4
MS&E 220	Probabilistic Analysis	3-4
STATS 110	Statistical Methods in Engineering and the Physical Sciences	5
STATS 116	Theory of Probability	4

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:

CS 106A	Programming Methodology	3-5

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

ii. Programming II

One of the following:

CS 106B	Programming Abstractions	3-5
CS 106X	Programming Abstractions (Accelerated)	3-5

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

One of the following:

CS 107	Computer Organization and Systems	3-5
CS 107E	Computer Systems from the Ground Up	3-5
CS 129	Applied Machine Learning	3-4
CS 147	Introduction to Human-Computer Interaction Design (Plus one of the following:)	3-5
CS 193A	Android Programming	3
CS 193C	Client-Side Internet Technologies	3
CS 193P	iOS Application Development	3
CS 193X	Web Programming Fundamentals	3
CS 194H	User Interface Design Project	3-4
CS 221	Artificial Intelligence: Principles and Techniques	3-4
CS 229	Machine Learning	3-4

d. Empirical Cognitive Science

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

i. Overview of psychology.

PSYCH 1	Introduction to Psychology	5

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

One of the following:

BIO 150	Human Behavioral Biology	5
LINGUIST 145	Introduction to Psycholinguistics	4
LINGUIST 150	Language and Society	3-4
PSYCH 30	Introduction to Perception	4
PSYCH 45	Introduction to Learning and Memory	3
PSYCH 50	Introduction to Cognitive Neuroscience	4
PSYCH 60	Introduction to Developmental Psychology	3
PSYCH 70	Self and Society: Introduction to Social Psychology	4
PSYCH 75	Introduction to Cultural Psychology	5
PSYCH 141	Cognitive Development	3
PSYCH 154	Judgment and Decision-Making	3

iii. Linguistic Theory

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

LINGUIST 105	Phonetics	4
LINGUIST 110	Introduction to Phonology	4
LINGUIST 120		
LINGUIST 130A	Introduction to Semantics and Pragmatics	4
LINGUIST 130B	Introduction to Lexical Semantics	3-4

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

LINGUIST 21N	Linguistic Diversity and Universals: The Principles of Language Structure	3
LINGUIST 30N	Linguistic Meaning and the Law	3
LINGUIST 121A	The Syntax of English	4
LINGUIST 121B	Crosslinguistic Syntax	4
LINGUIST 134A	The Structure of Discourse: Theory and Applications	2-4
LINGUIST 160	Introduction to Language Change	2-4

Cross-Area Requirement		
A non-introductory course, which has as a prerequisite at least one Core course (or equivalent), and which combines methods and subject matter from at least two Breadth areas in the Core. One of the following:		
i. Suggested courses for most students		
Only one course must be chosen to fulfill the requirement - categories are for guidance only:		
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.		
A list of approved Advanced Small Seminar Requirement options appears on the Symbolic Systems website at https://symsys.stanford.edu/undergraduatesmajor-requirementscore-requirements/advanced-small-seminar-requirement (https://symsys.stanford.edu/undergraduatesmajor-requirementscore-requirements/advanced-small-seminar-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

		Units
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

PSYCH 204	Computation and Cognition: The Probabilistic Approach	3
PSYCH 209	Neural Network Models of Cognition	4
PSYCH 221	Image Systems Engineering	1-3
PSYCH 242	Theoretical Neuroscience	3
PHIL 249		
Formal Methods and Empirical Cognitive Science		
PSYCH 253	Advanced Statistical Modeling	3
CS 229	Machine Learning	3-4
ECON 178	Behavioral Economics	5
LINGUIST 130A	Introduction to Semantics and Pragmatics	4
LINGUIST 180	From Languages to Information	3-4
PHIL 154	Modal Logic	4
PHIL 181	Philosophy of Language	4
PSYCH 204	Computation and Cognition: The Probabilistic Approach	3
PSYCH 209	Neural Network Models of Cognition	4
PSYCH 221	Image Systems Engineering	1-3
PSYCH 242	Theoretical Neuroscience	3
PSYCH 249	Large-Scale Neural Network Modeling for Neuroscience	1-3
PSYCH 253	Advanced Statistical Modeling	3
Computational Methods and Empirical Cognitive Science		
CS 147	Introduction to Human-Computer Interaction Design	3-5
CS 229	Machine Learning	3-4
CS 448B	Data Visualization	3-4
LINGUIST 130A	Introduction to Semantics and Pragmatics	4
LINGUIST 180	From Languages to Information	3-4
PHIL 167D	Philosophy of Neuroscience	4
PSYCH 164	Brain decoding	3
PSYCH 204	Computation and Cognition: The Probabilistic Approach	3
PSYCH 209	Neural Network Models of Cognition	4
PSYCH 221	Image Systems Engineering	1-3
PSYCH 204A	Human Neuroimaging Methods	3
PSYCH 242	Theoretical Neuroscience	3
PSYCH 249	Large-Scale Neural Network Modeling for Neuroscience	1-3
PSYCH 253	Advanced Statistical Modeling	3

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	
PSYCH 242	Theoretical Neuroscience	
PSYCH 247	Topics in Natural and Artificial Intelligence	
PSYCH 249	Large-Scale Neural Network Modeling for Neuroscience	
PSYCH 293	What makes a good explanation? Psychological and philosophical perspectives	
STATS 220	Machine Learning Methods for Neural Data Analysis	
SYMSYS 202	Theories of Consciousness	
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/undergraduatesconcentrations/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	

PHIL 134A	Phenomenology: Animals
PHIL 167D	Philosophy of Neuroscience
PHIL 168M	Biological Individuality
PHIL 178M	Introduction to Environmental Ethics
PHIL 360	Grad Seminar: Philosophy of Neuroscience
PHIL 368A	Topics in Neuroscience
SYMSYS 202	Theories of Consciousness
SYMSYS 205	The Philosophy and Science of Perception

Theoretical and Mathematical Approaches **3-5**

For example, any of the following:

BIO 183	Theoretical Population Genetics
BIO 223	Stochastic and Nonlinear Dynamics
BIO 251	Quantitative Evolutionary Dynamics and Genomics
BIODS 215	Topics in Biomedical Data Science: Large-scale inference
BIOMEDIN 219	Mathematical Models and Medical Decisions
ECON 136	Market Design
EE 102A	Signal Processing and Linear Systems I
HUMBIO 88	Introduction to Statistics for the Health Sciences
HUMBIO 89	Introduction to Health Sciences Statistics
HUMBIO 154B	Principles of Epidemiology
MS&E 292	Health Policy Modeling
STATS 141	Biostatistics
STATS 215	Statistical Models in Biology

Computational and Design Methods **3-5**

For example, any of the following:

BIODS 220	Artificial Intelligence in Healthcare
BIOE 313	Neuromorphics: Brains in Silicon
BIOMEDIN 210	Modeling Biomedical Systems
BIOMEDIN 260	Computational Methods for Biomedical Image Analysis and Interpretation
BIOMEDIN 273B	Deep Learning in Genomics and Biomedicine
BIOMEDIN 279	Computational Biology: Structure and Organization of Biomolecules and Cells
CS 247B	Design for Behavior Change
CS 247S	Service Design
CS 273A	The Human Genome Source Code
CS 372	Artificial Intelligence for Disease Diagnosis and Information Recommendations
CS 379C	Computational Models of the Neocortex
CS 448B	Data Visualization
GENE 211	Genomics
HUMBIO 51	Big Data for Biologists - Decoding Genomic Function
HUMBIO 151R	Biology, Health and Big Data
PSYC 223B	Topics in Neurodiversity: Design Thinking Approaches
PSYCH 204B	Computational Neuroimaging
STATS 220	Machine Learning Methods for Neural Data Analysis
SYMSYS 245	Cognition in Interaction Design

Experimental and Observational Science

For example, any of the following:

BIO 81	Introduction to Ecology
BIO 82	Genetics
BIO 84	Physiology
BIO 150	Human Behavioral Biology
BIO 151	Mechanisms of Neuron Death
BIO 204	Neuroplasticity: From Synapses to Behavior
BIODS 215	Topics in Biomedical Data Science: Large-scale inference
HUMBIO 51	Big Data for Biologists - Decoding Genomic Function
HUMBIO 151R	Biology, Health and Big Data
HUMBIO 154B	Principles of Epidemiology
MS&E 292	Health Policy Modeling
NBIO 206	The Nervous System
PSYC 124	Brain Plasticity
PSYCH 30	Introduction to Perception
PSYCH 45	Introduction to Learning and Memory
PSYCH 50	Introduction to Cognitive Neuroscience
PSYCH 60	Introduction to Developmental Psychology
PSYCH 121	Ion Transport and Intracellular Messengers
PSYCH 162	Brain Networks
PSYCH 169	Advanced Seminar on Memory
PSYCH 202	Cognitive Neuroscience
PSYCH 204A	Human Neuroimaging Methods
PSYCH 232	Brain and Decision
PSYCH 254	Affective Neuroscience

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).

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
PHIL 167D	Philosophy of Neuroscience
PHIL 168M	Biological Individuality
PHIL 178M	Introduction to Environmental Ethics
PHIL 360	Grad Seminar: Philosophy of Neuroscience
PHIL 368A	Topics in Neuroscience
PSYC 223B	Topics in Neurodiversity: Design Thinking Approaches
PSYCH 121	Ion Transport and Intracellular Messengers
PSYCH 162	Brain Networks

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: Precalculus
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

PHIL 186	Philosophy of Mind
PHIL 187	Philosophy of Action
PHIL 194D	Capstone Seminar: Artificial Intelligence
PHIL 351D	Measurement Theory
PHIL 360	Grad Seminar: Philosophy of Neuroscience
PHIL 368A	Topics in Neuroscience
PHIL 385D	Advanced Topics in Philosophy of Language
PHIL 386	Truth as the Aim of Belief and Inquiry
PSYCH 30	Introduction to Perception
PSYCH 45	Introduction to Learning and Memory
PSYCH 50	Introduction to Cognitive Neuroscience
PSYCH 70	Self and Society: Introduction to Social Psychology
PSYCH 75	Introduction to Cultural Psychology
PSYCH 140	Introduction to Psycholinguistics
PSYCH 141	Cognitive Development
PSYCH 154	Judgment and Decision-Making
PSYCH 160	Seminar on Emotion
PSYCH 162	Brain Networks
PSYCH 164	Brain decoding
PSYCH 169	Advanced Seminar on Memory
PSYCH 175	Social Cognition and Learning in Early Childhood
PSYCH 202	Cognitive Neuroscience
PSYCH 204	Computation and Cognition: The Probabilistic Approach
PSYCH 204A	Human Neuroimaging Methods
PSYCH 204B	Computational Neuroimaging
PSYCH 205	Foundations of Cognition
PSYCH 209	Neural Network Models of Cognition
PSYCH 221	Image Systems Engineering
PSYCH 232	Brain and Decision
PSYCH 249	Large-Scale Neural Network Modeling for Neuroscience
PSYCH 250	High-level Vision: From Neurons to Deep Neural Networks
PSYCH 254	Affective Neuroscience
PSYCH 266	Current Debates in Learning and Memory
PSYCH 287	Brain Machine Interfaces: Science, Technology, and Application
PSYCH 293	What makes a good explanation? Psychological and philosophical perspectives
SYMSYS 203	Cognitive Science Perspectives on Humanity and Well-Being
SYMSYS 207	Conceptual Issues in Cognitive Science
SYMSYS 208	Computer Machines and Intelligence

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 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 221	Artificial Intelligence: Principles and Techniques
CS 227B	General Game Playing
CS 228	Probabilistic Graphical Models: Principles and Techniques
CS 229	Machine Learning
CS 230	Deep Learning
CS 231A	Computer Vision: From 3D Reconstruction to Recognition
CS 234	Reinforcement Learning
CS 238	Decision Making under Uncertainty
CS 325B	Data for Sustainable Development
CS 379C	Computational Models of the Neocortex
EE 104	Introduction to Machine Learning
LINGUIST 180	From Languages to Information
MUSIC 220C	Research Seminar in Computer-Generated Music
MUSIC 257	Neuroplasticity and Musical Gaming
NBIO 101	Social and Ethical Issues in the Neurosciences
PHIL 134A	Phenomenology: Animals
PHIL 356C	Logic and Artificial Intelligence
PHIL 357	Research Seminar on Logic and Cognition
PHIL 359	Logic Spring Seminar
PHIL 360	Grad Seminar: Philosophy of Neuroscience
PHIL 368A	Topics in Neuroscience
PSYCH 164	Brain decoding
PSYCH 204	Computation and Cognition: The Probabilistic Approach
PSYCH 209	Neural Network Models of Cognition
PSYCH 242	Theoretical Neuroscience
PSYCH 247	Topics in Natural and Artificial Intelligence
PSYCH 249	Large-Scale Neural Network Modeling for Neuroscience
PSYCH 293	What makes a good explanation? Psychological and philosophical perspectives
STATS 220	Machine Learning Methods for Neural Data Analysis
SYMSYS 202	Theories of Consciousness
SYMSYS 205	The Philosophy and Science of Perception
SYMSYS 207	Conceptual Issues in Cognitive Science
SYMSYS 208	Computer Machines and Intelligence

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:

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/undergraduatesconcentrations/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.		
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 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/undergraduatesconcentrations/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
COMM 326	Advanced Topics in Human Virtual Representation
CS 181	Computers, Ethics, and Public Policy
CS 182	Ethics, Public Policy, and Technological Change
CS 206	Exploring Computational Journalism
CS 224W	Machine Learning with Graphs
CS 246	Mining Massive Data Sets
CS 278	Social Computing
CS 325B	Data for Sustainable Development
ECON 160	Game Theory and Economic Applications
ECON 178	Behavioral Economics
ECON 180	Honors Game Theory
MS&E 234	Data Privacy and Ethics
PHIL 171	Justice
PHIL 171P	20th Century Political Theory: Liberalism and its Critics
PHIL 359	Logic Spring Seminar
PSYCH 154	Judgment and Decision-Making
PSYCH 262	Measurement and the Study of Change in Social Science Research
PSYCH 290	Natural Language Processing & Text-Based Machine Learning in the Social Sciences
PSYCH 293	What makes a good explanation? Psychological and philosophical perspectives
SOC 154	The Politics of Algorithms

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
STS 191W	Doing STS: 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 of more.

Computer-Generated Music I		**3-5**
MUSIC 220A	Fundamentals of Computer-Generated Sound	
Computer-Generated Music II		**3-5**
MUSIC 220B	Compositional Algorithms, Psychoacoustics, and Computational Music	
Music and the Mind & Brain		**3-5**
Select one of the following:		
MUSIC 1A	Music, Mind, and Human Behavior	
MUSIC 251	Psychophysics and Music Cognition	
MUSIC 351A	Seminar in Music Perception and Cognition I	
PSYCH 30	Introduction to Perception	
PSYCH 50	Introduction to Cognitive Neuroscience	
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).		
MUSIC 128	Stanford Laptop Orchestra: Composition, Coding, and Performance	
MUSIC 220C	Research Seminar in Computer-Generated Music	
MUSIC 250A	Physical Interaction Design for Music	
MUSIC 251	Psychophysics and Music Cognition	
MUSIC 253	Symbolic Musical Information	
MUSIC 254	Computational Music Analysis	
MUSIC 256A	Music, Computing, Design: The Art of Design	
MUSIC 257	Neuroplasticity and Musical Gaming	

MUSIC 351A	Seminar in Music Perception and Cognition I

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 108	Object-Oriented Systems Design
LINGUIST 105	Phonetics
LINGUIST 110	Introduction to Phonology
MUSIC 1A	Music, Mind, and Human Behavior
MUSIC 222	Sound in Space

Total Units **15-25**

Decision Making and Rationality (DMAR)

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

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:

MS&E 234	Data Privacy and Ethics
MS&E 254	The Ethical Analyst
PHIL 133S	Heidegger and Mysticism
PHIL 169	Evolution of the Social Contract
PHIL 170	Ethical Theory
PHIL 171	Justice
PHIL 172	History of Modern Moral Philosophy
PHIL 184	Topics in Epistemology
PHIL 184B	Formal Epistemology
PHIL 187	Philosophy of Action
PHIL 359	Logic Spring Seminar
PHIL 388	Topics in Normativity
POLISCI 131L	Modern Political Thought: Machiavelli to Marx and Mill
POLISCI 230A	Classical Seminar: Origins of Political Thought
PSYCH 160	Seminar on Emotion

Formal Decision Theories **3-5**

Select one of the following:

ECON 51	Economic Analysis II
ECON 136	Market Design
ECON 160	Game Theory and Economic Applications
ECON 180	Honors Game Theory
ECON 289	Advanced Topics in Game Theory and Information Economics
MS&E 232	Introduction to Game Theory
MS&E 232H	Introduction to Game Theory
PHIL 154	Modal Logic
PHIL 351D	Measurement Theory
PHIL 359	Logic Spring Seminar
POLISCI 356A	Formal Theory I: Game Theory for Political Science
PUBLPOL 51	Microeconomics for Policy

Empirical Findings and Explanations **3-5**

Select one of the following:

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

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:

BIOMEDIN 219	Mathematical Models and Medical Decisions
BIOMEDIN 251	Outcomes Analysis
CEE 206	Decision Analysis for Civil and Environmental Engineers
COMM 106	Communication Research Methods
COMM 124	Truth, Trust, and Tech
CS 181	Computers, Ethics, and Public Policy
CS 182	Ethics, Public Policy, and Technological Change
CS 228	Probabilistic Graphical Models: Principles and Techniques
CS 234	Reinforcement Learning
CS 238	Decision Making under Uncertainty
CS 239	Advanced Topics in Sequential Decision Making
CS 261	Optimization and Algorithmic Paradigms
CS 325B	Data for Sustainable Development
ECON 50	Economic Analysis I
ECON 102B	Applied Econometrics
ECON 102C	Advanced Topics in Econometrics
ECON 135	Foundations of Finance
ECON 136	Market Design
ECON 137	Decision Modeling and Information
ECON 141	Public Finance and Fiscal Policy
ECON 150	Economic Policy Analysis
ECON 155	Environmental Economics and Policy
ECON 162	Games Developing Nations Play

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).	
CS 181	Computers, Ethics, and Public Policy
CS 182	Ethics, Public Policy, and Technological Change
CS 228	Probabilistic Graphical Models: Principles and Techniques
CS 234	Reinforcement Learning
CS 238	Decision Making under Uncertainty
CS 239	Advanced Topics in Sequential Decision Making
CS 261	Optimization and Algorithmic Paradigms
CS 325B	Data for Sustainable Development
PHIL 184	Topics in Epistemology
PHIL 184B	Formal Epistemology
PHIL 187	Philosophy of Action
PHIL 359	Logic Spring Seminar
PSYCH 154	Judgment and Decision-Making
PSYCH 160	Seminar on Emotion
PSYCH 223	Social Norms
PSYCH 232	Brain and Decision
PSYCH 254	Affective Neuroscience
SYMSYS 201	Digital Technology, Society, and Democracy
SYMSYS 203	Cognitive Science Perspectives on Humanity and Well-Being
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:	
ECON 102D	Econometric Methods for Public Policy Analysis and Business Decision-Making
ECON 151	Tackling Big Questions Using Social Data Science
MS&E 33N	How We Decide: Social Choice in the Age of Algorithms
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/undergraduatesconcentrations/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:	
CS 181	Computers, Ethics, and Public Policy
CS 182	Ethics, Public Policy, and Technological Change
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:	
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 120W	The Rise of Digital Culture
COMM 124	Truth, Trust, and Tech
COMM 145	Personality and Digital Media
COMM 154	The Politics of Algorithms
COMM 172	Media Psychology

COMM 184	Race and Media
COMM 322	Advanced Studies in Behavior and Social Media
CS 209	Law, Order, & Algorithms
ENGLISH 106A	A.I.-Activism-Art
INTLPOL 221	Politics of Data: Algorithmic Culture, Big Data, and Information Waste
LAW 4039	Regulating Artificial Intelligence
LAW 4045	Digital Technology and Law: Foundations
LAW 4050	AI and Rule of Law: A Global Perspective
MS&E 184	Future of Work: Issues in Organizational Learning and Design
MS&E 234	Data Privacy and Ethics
NBIO 101	Social and Ethical Issues in the Neurosciences
PHIL 174B	Universal Basic Income: the philosophy behind the proposal
SOC 124	Gender and Technology
STS 1	The Public Life of Science and Technology
SYMSYS 201	Digital Technology, Society, and Democracy

Augmenting Human Capabilities **3-5**

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 **3-5**

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: Principles and Techniques
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 **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 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

EDUC 266	Educational Neuroscience
EDUC 281	Technology for Learners
LINGUIST 180	From Languages to Information
LINGUIST 285	Spoken Language Processing
PHIL 167D	Philosophy of Neuroscience
PHIL 168M	Biological Individuality
PHIL 359	Logic Spring Seminar
PHIL 360	Grad Seminar: Philosophy of Neuroscience
PHIL 368A	Topics in Neuroscience
PHIL 385D	Advanced Topics in Philosophy of Language
PHIL 386	Truth as the Aim of Belief and Inquiry
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 121	Ion Transport and Intracellular Messengers
PSYCH 145	Seminar on Infant Development
PSYCH 154	Judgment and Decision-Making
PSYCH 162	Brain Networks
PSYCH 164	Brain decoding
PSYCH 169	Advanced Seminar on Memory
PSYCH 202	Cognitive Neuroscience
PSYCH 204	Computation and Cognition: The Probabilistic Approach
PSYCH 209	Neural Network Models of Cognition
PSYCH 232	Brain and Decision
PSYCH 242	Theoretical Neuroscience
PSYCH 247	Topics in Natural and Artificial Intelligence
PSYCH 249	Large-Scale Neural Network Modeling for Neuroscience
PSYCH 254	Affective Neuroscience
PSYCH 273	Changing Mindsets and Contexts: How to Create Authentic, Lasting Improvement
PSYCH 293	What makes a good explanation? Psychological and philosophical perspectives
STATS 216	Introduction to Statistical Learning
STATS 220	Machine Learning Methods for Neural Data Analysis
STATS 315B	Modern Applied Statistics: Data Mining
SYMSYS 202	Theories of Consciousness
SYMSYS 205	The Philosophy and Science of Perception
SYMSYS 245	Cognition in Interaction Design
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:	
PHIL 20N	Philosophy of Artificial Intelligence
STATS 191	Introduction to Applied Statistics
STATS 200	Introduction to Statistical Inference
Total Units	**15-25**

Human-Computer Interaction

See also the Symbolic Systems website (https://symsys.stanford.edu/undergraduatesconcentrations/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.		
Introduction to HCI		**3-5**
CS 147	Introduction to Human-Computer Interaction Design	
Design Methods		**3-5**
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:		
CS 194H	User Interface Design Project	
CS 247A	Design for Artificial Intelligence	
CS 247B	Design for Behavior Change	
CS 247G	Introduction to Game Design	
CS 247S	Service Design	
HCI Theory		**3-5**
Courses teaching design, behavioral, and critical theories that underlie the design process. One of the following:		
COMM 145	Personality and Digital Media	
COMM 166	Virtual People	
COMM 172	Media Psychology	
CS 347	Human-Computer Interaction: Foundations and Frontiers	
ME 341	Design Experiments	
User Interface Implementation		**3-5**
An advanced course in programming for user interfaces. One of the following:		
CS 108	Object-Oriented Systems Design	
CS 142	Web Applications	
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 120W	The Rise of Digital Culture	
COMM 145	Personality and Digital Media	
COMM 166	Virtual People	
COMM 172	Media Psychology	
COMM 322	Advanced Studies in Behavior and Social Media	
COMM 324	Language and Technology	
COMM 326	Advanced Topics in Human Virtual Representation	
CS 181	Computers, Ethics, and Public Policy	
CS 182	Ethics, Public Policy, and Technological Change	

CS 206	Exploring Computational Journalism
CS 247I	Design for Understanding
CS 278	Social Computing
CS 347	Human-Computer Interaction: Foundations and Frontiers
CS 377E	Designing Solutions to Global Grand Challenges
CS 377G	Designing Serious Games
CS 377Q	Designing for Accessibility
CS 377U	Understanding Users
EDUC 230	Learning Experience Design
EDUC 281	Technology for Learners
EDUC 302	Behavior Design: Clubhouse for Helping People with Good Habits & Behavior Change
EDUC 342	Child Development and New Technologies
EDUC 391	Engineering Education and Online Learning
ME 115B	Product Design Methods
ME 341	Design Experiments
SYMSYS 201	Digital Technology, Society, and Democracy
SYMSYS 245	Cognition in Interaction Design
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 d.school course worth 3 or more units	
ARTSTUDI 130	Interactive Art: Making it with Arduino
ARTSTUDI 142	Mixed-Media Drawing: Art & Aesthetics of Social Media
ARTSTUDI 160	Intro to Digital / Physical Design
ARTSTUDI 168	Data as Material
ARTSTUDI 179	Digital Art I
COMM 1	Introduction to Communication
COMM 1B	Media, Culture, and Society
COMM 106	Communication Research Methods
COMM 124	Truth, Trust, and Tech
COMM 154	The Politics of Algorithms
COMM 230A	Digital Civil Society
COMM 230B	Digital Civil Society
COMM 230C	Digital Civil Society
COMM 314	Ethnographic Methods
CS 80Q	Race and Gender in Silicon Valley
EDUC 423	Introduction to Data Science
ENGR 150	Data Challenge Lab
HUMBIO 82A	Qualitative Research Methodology
ME 101	Visual Thinking
ME 105	Designing for Impact
ME 115A	Introduction to Human Values in Design
ME 203	Design and Manufacturing
ME 210	Introduction to Mechatronics
ME 216A	Advanced Product Design: Needfinding
MED 147	Methods in Community Assessment, Evaluation, and Research
MED 275B	Biodesign Fundamentals
MS&E 125	Introduction to Applied Statistics
MS&E 135	Networks
MS&E 234	Data Privacy and Ethics
PHIL 71H	Introduction to Aesthetics
PSYCH 10	Introduction to Statistical Methods: Precalculus
SOC 167VP	Justice + Poverty Innovation:Create new solutions for people to navigate housing, medical, & debt
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 263	Design of Experiments
STS 1	The Public Life of Science and Technology
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	**3-5**
CS 205L	Continuous Mathematical Methods with an Emphasis on Machine Learning
CS 221	Artificial Intelligence: Principles and Techniques
CS 224N	Natural Language Processing with Deep Learning
CS 228	Probabilistic Graphical Models: Principles and Techniques
CS 229	Machine Learning
CS 229M	Machine Learning Theory
CS 230	Deep Learning
CS 234	Reinforcement Learning
CS 236	Deep Generative Models
CS 325B	Data for Sustainable Development
EE 104	Introduction to Machine Learning
LINGUIST 180	From Languages to Information
MS&E 234	Data Privacy and Ethics
PSYCH 204	Computation and Cognition: The Probabilistic Approach
PSYCH 209	Neural Network Models of Cognition
PSYCH 249	Large-Scale Neural Network Modeling for Neuroscience
STATS 101	Data Science 101
STATS 220	Machine Learning Methods for Neural Data Analysis
STATS 315A	Modern Applied Statistics: Learning
STATS 315B	Modern Applied Statistics: Data Mining

Human Learning		**3-5**
EDUC 101	Introduction to Teaching and Learning	
EDUC 115N	How to Learn Mathematics	
EDUC 218	Topics in Cognition and Learning: Technology and Multitasking	
EDUC 266	Educational Neuroscience	
EDUC 368	Cognitive Development in Childhood and Adolescence	
EDUC 378	Social and Emotional Learning: Conceptual & Measurement Issues	
LINGUIST 140	Learning to Speak: An Introduction to Child Language Acquisition	
PSYCH 45	Introduction to Learning and Memory	
PSYCH 50	Introduction to Cognitive Neuroscience	
PSYCH 60	Introduction to Developmental Psychology	
PSYCH 141	Cognitive Development	
PSYCH 169	Advanced Seminar on Memory	
PSYCH 175	Social Cognition and Learning in Early Childhood	
PSYCH 202	Cognitive Neuroscience	
PSYCH 204	Computation and Cognition: The Probabilistic Approach	
PSYCH 209	Neural Network Models of Cognition	
PSYCH 249	Large-Scale Neural Network Modeling for Neuroscience	
PSYCH 251	Experimental Methods	
PSYCH 265	Social Psychology and Social Change	
PSYCH 266	Current Debates in Learning and Memory	
Learning Environment Design		**3-5**
COMM 322	Advanced Studies in Behavior and Social Media	
CS 147	Introduction to Human-Computer Interaction Design	
CS 194H	User Interface Design Project	
EDUC 211	Beyond Bits and Atoms - Lab	
EDUC 230	Learning Experience Design	
EDUC 236	Beyond Bits and Atoms: Designing Technological Tools	
EDUC 281	Technology for Learners	
EDUC 298	Seminar on Teaching Introductory Computer Science	
EDUC 328	Topics in Learning and Technology: Core Mechanics for Learning	
EDUC 333A	Understanding Learning Environments	
EDUC 342	Child Development and New Technologies	
EDUC 391	Engineering Education and Online Learning	
EDUC 426	Unleashing Personal Potential: Behavioral Science and Design Thinking Applied to Self	
MUSIC 257	Neuroplasticity and Musical Gaming	
PSYCH 287	Brain Machine Interfaces: Science, Technology, and Application	
SYMSYS 245	Cognition in Interaction Design	
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 326	Advanced Topics in Human Virtual Representation	
CS 181	Computers, Ethics, and Public Policy	
CS 182	Ethics, Public Policy, and Technological Change	
CS 221	Artificial Intelligence: Principles and Techniques	
CS 228	Probabilistic Graphical Models: Principles and Techniques	
CS 229	Machine Learning	
CS 229M	Machine Learning Theory	
CS 230	Deep Learning	
CS 231A	Computer Vision: From 3D Reconstruction to Recognition	
CS 234	Reinforcement Learning	
CS 379C	Computational Models of the Neocortex	
EDUC 251	Topics in Epistemology and Education	
EDUC 261E	Curriculum and Instruction Elective in Data Science	
EE 104	Introduction to Machine Learning	
LINGUIST 180	From Languages to Information	
PHIL 184B	Formal Epistemology	
PSYCH 204	Computation and Cognition: The Probabilistic Approach	
PSYCH 209	Neural Network Models of Cognition	
PSYCH 242	Theoretical Neuroscience	
PSYCH 247	Topics in Natural and Artificial Intelligence	
PSYCH 249	Large-Scale Neural Network Modeling for Neuroscience	
PSYCH 262	Measurement and the Study of Change in Social Science Research	
PSYCH 273	Changing Mindsets and Contexts: How to Create Authentic, Lasting Improvement	
PSYCH 293	What makes a good explanation? Psychological and philosophical perspectives	
STATS 220	Machine Learning Methods for Neural Data Analysis	
SYMSYS 245	Cognition in Interaction Design	
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:		
PSYCH 10	Introduction to Statistical Methods: Precalculus	
STATS 191	Introduction to Applied Statistics	
STATS 200	Introduction to Statistical Inference	
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/undergraduatesconcentrations/media-and-communication-mediacomm-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		**3-5**
COMM 1	Introduction to Communication	
Statistical and Data Analysis Methods		**3-5**

Select one of the following:

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

COMM 172	Media Psychology
COMM 180	Ethics, Public Policy, and Technological Change
COMM 184	Race and Media
COMM 186W	Media, Technology, and the Body
COMM 230A	Digital Civil Society
COMM 322	Advanced Studies in Behavior and Social Media
CS 181	Computers, Ethics, and Public Policy
CS 182	Ethics, Public Policy, and Technological Change
CS 209	Law, Order, & Algorithms
ECON 46	Networks and Human Behavior
ECON 47	Media Markets and Social Good
ENGLISH 106A	A.I.-Activism-Art
INTLPOL 221	Politics of Data: Algorithmic Culture, Big Data, and Information Waste
LAW 4039	Regulating Artificial Intelligence
LAW 4045	Digital Technology and Law: Foundations
LAW 4050	AI and Rule of Law: A Global Perspective
LINGUIST 156	Language, Gender, & Sexuality
MS&E 135	Networks
MS&E 184	Future of Work: Issues in Organizational Learning and Design
MS&E 234	Data Privacy and Ethics
NBIO 101	Social and Ethical Issues in the Neurosciences
PHIL 174B	Universal Basic Income: the philosophy behind the proposal
POLISCI 223A	Public Opinion and American Democracy
POLISCI 227C	Money in Politics
PSYC 86Q	Psychology of Xenophobia
PSYCH 103	Intergroup Communication
SOC 31N	Social Networks
SOC 124	Gender and Technology
SOC 126	Introduction to Social Networks
SOC 141P	Public Interest Tech: Case Studies
STS 1	The Public Life of Science and Technology
SYMSYS 201	Digital Technology, Society, and Democracy
Integrative Requirement	**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).

COMM 164	The Psychology of Communication About Politics in America
COMM 166	Virtual People
COMM 172	Media Psychology
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
COMM 322	Advanced Studies in Behavior and Social Media
COMM 324	Language and Technology
COMM 326	Advanced Topics in Human Virtual Representation
CS 181	Computers, Ethics, and Public Policy
CS 182	Ethics, Public Policy, and Technological Change
CS 206	Exploring Computational Journalism
CS 224W	Machine Learning with Graphs
CS 278	Social Computing
LINGUIST 134A	The Structure of Discourse: Theory and Applications
LINGUIST 150	Language and Society
SOC 154	The Politics of Algorithms
SYMSYS 201	Digital Technology, Society, and Democracy
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 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 (see area 9) must be completed to total 5 courses beyond those that are taken for the Core.

Mathematical/Computational Foundations	**3-5**
CS 154	Introduction to the Theory of Computation

CS 221	Artificial Intelligence: Principles and Techniques	
CS 229	Machine Learning	
PHIL 154	Modal Logic	
PSYCH 204	Computation and Cognition: The Probabilistic Approach	
PSYCH 209	Neural Network Models of Cognition	
PSYCH 251	Experimental Methods	
PSYCH 254	Affective Neuroscience	
Computational Linguistics		**3-5**
CS 124	From Languages to Information	
CS 224N	Natural Language Processing with Deep Learning	
CS 224S	Spoken Language Processing	
CS 224U	Natural Language Understanding	
CS 276	Information Retrieval and Web Search	
PSYCH 290	Natural Language Processing & Text-Based Machine Learning in the Social Sciences	
SYMSYS 112	Challenges for Language Systems	
Phonetics/Phonology/Speech		**3-5**
LINGUIST 105	Phonetics	
LINGUIST 110	Introduction to Phonology	
LINGUIST 112	Seminar in Phonology: Stress, Tone, and Accent	
LINGUIST 157	Sociophonetics	
LINGUIST 207A	Advanced Phonetics	
LINGUIST 210A	Phonology	
LINGUIST 260A	Historical Morphology and Phonology	
Morphosyntax		**3-5**
LINGUIST 121A	The Syntax of English	
LINGUIST 121B	Crosslinguistic Syntax	
LINGUIST 217	Morphosyntax	
LINGUIST 222A	Foundations of Syntactic Theory I	
LINGUIST 225D	Seminar in Syntax: Advanced Topics	
LINGUIST 260B	Historical Morphosyntax	
Semantics/Pragmatics/Philosophy of Language		**3-5**
LINGUIST 130A	Introduction to Semantics and Pragmatics	
LINGUIST 130B	Introduction to Lexical Semantics	
LINGUIST 132	Lexical Semantic Typology	
LINGUIST 230B	Advanced Semantics	
LINGUIST 230C	Advanced Topics in Semantics & Pragmatics	
LINGUIST 232A	Lexical Semantics	
LINGUIST 236	Seminar in Semantics: Conditionals	
PHIL 137	Wittgenstein	
PHIL 181	Philosophy of Language	
PHIL 182A	Naturalizing Representation	
PHIL 194D	Capstone Seminar: Artificial Intelligence	
PHIL 348	Evolution of Signalling	
PHIL 385D	Advanced Topics in Philosophy of Language	
SYMSYS 112	Challenges for Language Systems	
Psycholinguistics		**3-5**
LINGUIST 140	Learning to Speak: An Introduction to Child Language Acquisition	
LINGUIST 245B	Methods in Psycholinguistics	
PSYCH 132	Language and Thought	
PSYCH 140	Introduction to Psycholinguistics	
PSYCH 209	Neural Network Models of Cognition	
Sociolinguistics and Language Change		**3-5**
LINGUIST 65	African American Vernacular English	
LINGUIST 116A	Introduction to Word-Formation	
LINGUIST 150	Language and Society	
LINGUIST 150E	Who Speaks Good English	
LINGUIST 152	Sociolinguistics and Pidgin Creole Studies	
LINGUIST 156	Language, Gender, & Sexuality	
LINGUIST 157	Sociophonetics	
LINGUIST 168	Introduction to Linguistic Typology	
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	
CS 221	Artificial Intelligence: Principles and Techniques	
CS 276	Information Retrieval and Web Search	
LINGUIST 180	From Languages to Information	
PHIL 137	Wittgenstein	
PHIL 181	Philosophy of Language	
PHIL 182A	Naturalizing Representation	
PHIL 194D	Capstone Seminar: Artificial Intelligence	
PHIL 348	Evolution of Signalling	
PHIL 356C	Logic and Artificial Intelligence	
PHIL 357	Research Seminar on Logic and Cognition	
PHIL 359	Logic Spring Seminar	
PHIL 385D	Advanced Topics in Philosophy of Language	
PSYCH 204	Computation and Cognition: The Probabilistic Approach	
PSYCH 209	Neural Network Models of Cognition	
PSYCH 247	Topics in Natural and Artificial Intelligence	
SYMSYS 205	The Philosophy and Science of Perception	
SYMSYS 207	Conceptual Issues in Cognitive Science	
Contingent Electives		**3-5**
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:		
PSYCH 10	Introduction to Statistical Methods: Precalculus	
STATS 191	Introduction to Applied Statistics	
STATS 200	Introduction to Statistical Inference	
Additional courses may be added here in the future.		
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 of 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	
PSYCH 121	Ion Transport and Intracellular Messengers	
PSYCH 141	Cognitive Development	
PSYCH 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	
PSYCH 30	Introduction to Perception	
PSYCH 45	Introduction to Learning and Memory	
PSYCH 50	Introduction to Cognitive Neuroscience	
PSYCH 162	Brain Networks	
PSYCH 169	Advanced Seminar on Memory	
PSYCH 232	Brain and Decision	
PSYCH 254	Affective Neuroscience	
PSYCH 266	Current Debates in Learning and Memory	

Computational Approaches		**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	
PSYCH 164	Brain decoding	
PSYCH 204	Computation and Cognition: The Probabilistic Approach	
PSYCH 204A	Human Neuroimaging Methods	
PSYCH 204B	Computational Neuroimaging	
PSYCH 209	Neural Network Models of Cognition	
PSYCH 249	Large-Scale Neural Network Modeling for Neuroscience	
PSYCH 287	Brain Machine Interfaces: Science, Technology, and Application	
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	
PSYCH 30	Introduction to Perception	
PSYCH 221	Image Systems Engineering	
PSYCH 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	
PSYCH 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	
PSYCH 10	Introduction to Statistical Methods: Precalculus	
PSYCH 187	Research Methods in Cognition & Development	
PSYCH 204A	Human Neuroimaging Methods	
PSYCH 251	Experimental Methods	
PSYCH 252	Statistical Methods for Behavioral and Social Sciences	
PSYCH 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).	
CS 131	Computer Vision: Foundations and Applications
CS 221	Artificial Intelligence: Principles and Techniques
CS 228	Probabilistic Graphical Models: Principles and Techniques
CS 229	Machine Learning
CS 230	Deep Learning
CS 231A	Computer Vision: From 3D Reconstruction to Recognition
CS 234	Reinforcement Learning
CS 379C	Computational Models of the Neocortex
PHIL 167D	Philosophy of Neuroscience
PHIL 357	Research Seminar on Logic and Cognition
PHIL 360	Grad Seminar: Philosophy of Neuroscience
PHIL 368A	Topics in Neuroscience
PSYC 223B	Topics in Neurodiversity: Design Thinking Approaches
PSYCH 121	Ion Transport and Intracellular Messengers
PSYCH 162	Brain Networks
PSYCH 164	Brain decoding
PSYCH 169	Advanced Seminar on Memory
PSYCH 202	Cognitive Neuroscience
PSYCH 204	Computation and Cognition: The Probabilistic Approach
PSYCH 204A	Human Neuroimaging Methods
PSYCH 204B	Computational Neuroimaging
PSYCH 209	Neural Network Models of Cognition
PSYCH 232	Brain and Decision
PSYCH 242	Theoretical Neuroscience
PSYCH 247	Topics in Natural and Artificial Intelligence
PSYCH 249	Large-Scale Neural Network Modeling for Neuroscience
PSYCH 254	Affective Neuroscience
STATS 220	Machine Learning Methods for Neural Data Analysis
SYMSYS 202	Theories of Consciousness
SYMSYS 205	The Philosophy and Science of Perception
SYMSYS 207	Conceptual Issues in Cognitive Science
SYMSYS 245	Cognition in Interaction Design
Contingent Electives	**3-5**
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	**3-5**
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:	
NSUR 239	NeuroTech Training Seminar
NSUR 249	Experimental Immersion in Neuroscience
Total Units	**15-25**

Philosophical Foundations

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

		Units
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		**3-5**
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		**3-5**
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		**3-5**
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		**3-5**
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).	
CS 181	Computers, Ethics, and Public Policy
CS 182	Ethics, Public Policy, and Technological Change
NBIO 101	Social and Ethical Issues in the Neurosciences
PHIL 134A	Phenomenology: Animals
PHIL 162	Philosophy of Mathematics
PHIL 167D	Philosophy of Neuroscience
PHIL 169	Evolution of the Social Contract
PHIL 184B	Formal Epistemology
PHIL 194D	Capstone Seminar: Artificial Intelligence
PHIL 194Y	Capstone seminar: Common Sense Philosophy
PHIL 350	What makes a good explanation? Psychological and philosophical perspectives
PHIL 359	Logic Spring Seminar
PHIL 360	Grad Seminar: Philosophy of Neuroscience
PHIL 368A	Topics in Neuroscience
PHIL 385B	Topics in Metaphysics and Epistemology: Situations and Attitudes
PSYCH 160	Seminar on Emotion
SYMSYS 202	Theories of Consciousness
SYMSYS 205	The Philosophy and Science of Perception
SYMSYS 207	Conceptual Issues in Cognitive Science
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) web site for information on UAR grants and scholarships supporting student research projects at all levels.

Honors Program

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

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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

		Units
One course in each of the following core areas (please note that several of these courses have prerequisites):		
a. Cognition		**3-4**
Select one of the following:		
SYMSYS 1	Minds and Machines (formerly SYMSYS 100)	
PSYCH 45	Introduction to Learning and Memory	
PSYCH 50	Introduction to Cognitive Neuroscience	

b. Logic and Computation		**3-5**
Select one of the following:		
PHIL 150	Mathematical Logic	
PHIL 151	Metalogic	
CS 103	Mathematical Foundations of Computing	
c. Computer Programming		**3-5**
Select one of the following:		
CS 106B	Programming Abstractions	
CS 106X	Programming Abstractions	
CS 107	Computer Organization and Systems	
d. Philosophical Foundations		**4-5**
Select one of the following:		
SYMSYS 1	Minds and Machines (formerly SYMSYS 100)	
PHIL 80	Mind, Matter, and Meaning	
e. Linguistic Theory		**3-4**
Select one of the following:		
LINGUIST 105	Phonetics	
LINGUIST 110	Introduction to Phonology	
LINGUIST 120		
LINGUIST 121A	The Syntax of English	
LINGUIST 121B	Crosslinguistic Syntax	
LINGUIST 130A	Introduction to Semantics and Pragmatics	
LINGUIST 130B	Introduction to Lexical Semantics	
f. Computation and Cognition		**3-4**
Select one of the following:		
APPPHYS 293	Theoretical Neuroscience	
CS 221	Artificial Intelligence: Principles and Techniques	
CS 228	Probabilistic Graphical Models: Principles and Techniques	
CS 229	Machine Learning	
CS 131	Computer Vision: Foundations and Applications	
LINGUIST 180	From Languages to Information	
LINGUIST 182	(no longer offered)	
NENS 220		
PSYCH 109		
PSYCH 204	Computation and Cognition: The Probabilistic Approach	
PSYCH 209	Neural Network Models of Cognition	
Total Units		**19**

[1] SYMSYS 1 Minds and Machines (formerly SYMSYS 100) may not be counted for both areas 'a' and 'd'.

Option 2

Introduction		**4**
SYMSYS 1	Minds and Machines (formerly SYMSYS 100)	4
Interdisciplinary Concentration		**15**
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.		
Total Units		**19**

Coterminal Master's Degrees in Symbolic Systems

The Symbolic Systems M.S. Program admits a handful of coterminal students each year. Coterminal students usually complete the program in one academic year.

Applications for Coterminal admission of active Stanford undergraduates are reviewed in the Winter and Spring Quarters. For more details, see the Coterm admissions information (https://symsys.stanford.edu/graduatesms-admissions/coterminal-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 "Coterminal Master's Program (http://exploredegrees.stanford.edu/cotermdegrees/)" section. University requirements for the master's degree are described in the "Graduate Degrees (http://exploredegrees.stanford.edu/graduatedegrees/#masterstext)" section of this bulletin.

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

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

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

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

Master of Science in Symbolic Systems

The University's basic requirements for the M.S. degree are discussed in the "Graduate Degrees (http://exploredegrees.stanford.edu/graduatedegrees/)" section of this bulletin.

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

faculty adviser who is affiliated with the Symbolic Systems Program. The faculty adviser may impose requirements beyond those described here.

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

Note, the GRE is required for external applicants.

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

Director of Graduate Studies: Hyowon Gweon

Degree Requirements

A candidate for the M.S. degree in Symbolic Systems must complete a program of 45 units. All courses must be 100-level and above. At least 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 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

4. Completion of three quarters of SYMSYS 291 Master's Program Seminar.

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

COVID-19 Policies

On July 30, the Academic Senate adopted grading policies effective for all undergraduate and graduate programs, excepting the professional Graduate School of Business, School of Law, and the School of Medicine M.D. Program. For a complete list of those and other academic policies relating to the pandemic, see the "COVID-19 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'- 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 advisers guide students in key areas such as selecting courses, designing and conducting research, developing of teaching pedagogy, navigating policies and degree requirements, and exploring academic opportunities and professional pathways.

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

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

Faculty

Director: Michael C. Frank

Director of Graduate Studies: Hyowon Gweon

Associate Director: Todd Davies

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

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

Program Faculty:

Aeronautics and Astronautics: Mykel Kochenderfer (Assistant Professor)

Biology: Deborah Gordon (Professor)

Classics: Reviel Netz (Professor)

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

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

Economics: Muriel Niederle (Professor)

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

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

French and Italian: Jean-Pierre Dupuy (Professor)

Genetics: Russ B. Altman (Professor)

Graduate School of Business: Amir Goldberg (Associate Professor), Michal Kosinski (Associate Professor), Baba Shiv (Professor)

History: Jessica G. Riskin (Professor)

Law: Daniel Ho, (Professor), Mark Lemley (Professor)

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

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

Mathematics: Persi Diaconis (Professor)

Mechanical Engineering: Sean Follmer (Assistant Professor)

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

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

Neurobiology: Keren Haroush (Assistant Professor), William T. Newsome (Professor), Jennifer Raymond (Professor)

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

Psychiatry and Behavioral Sciences: Vinod Menon (Professor)

Psychology: Herbert H. Clark (Professor, emeritus), Johannes Eichstaedt (Assistant Professor), Anne Fernald (Associate Professor), Michael C. Frank (Associate Professor), Justin Gardner (Assistant Professor), Noah Goodman (Associate Professor), Kalanit Grill-Spector (Professor), Hyowon Gweon (Assistant Professor), Brian Knutson (Professor), Ellen Markman (Professor), James McClelland (Professor), Russell Poldrack (Professor), Barbara Tversky (Professor, emerita), Anthony Wagner (Professor), Brian Wandell (Professor), Daniel Yamins (Assistant Professor), Jamil Zaki (Assistant Professor)

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

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

Other Affiliates: David Barker-Plummer (CSLI Engineering Research Associate), Keith Devlin H-STAR Operation Senior Researcher), Daniel Flickinger (CSLI Research and Development Engineer), Cheryl Phillips (Lecturer in Communications)

Courses

SYMSYS 1. Minds and Machines. 4 Units.
(Formerly SYMSYS 100). An overview of the interdisciplinary study of cognition, information, communication, and language, with an emphasis on foundational issues: What are minds? What is computation? What are rationality and intelligence? Can we predict human behavior? Can computers be truly intelligent? How do people and technology interact, and how might they do so in the future? Lectures focus on how the methods of philosophy, mathematics, empirical research, and computational modeling are used to study minds and machines. Students must take this course before being approved to declare Symbolic Systems as a major. All students interested in studying Symbolic Systems are urged to take this course early in their student careers. The course material and presentation will be at an introductory level, without prerequisites. 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?nThe 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 a statistical model 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. nThe focus of CS247g is an introduction to theory and practice of the design of games. We will make digital and paper games, do rapid iteration and run user research studies appropriate to game design. This class has multiple short projects, allowing us to cover a variety of genres, from narrative to pure strategy. Prerequisites: 147 or equivalent background.
Same as: CS 247G

SYMSYS 195I. Image Systems Engineering. 1-3 Unit.
This course is an introduction to digital imaging technologies. We focus on the principles of key elements of digital systems components; we show how to use simulation to predict how these components will work together in a complete image system simulation. The early lectures introduce the software environment and describe options for the course project. The following topics are covered and software tools are introduced:n- Basic principles of optics (Snell's Law, diffraction, adaptive optics).n- Image sensor and pixel designsn- Color science, metrics, and calibrationn- Human spatial resolutionn- Image processing principlesn- Display technologiesnA special theme of this course is that it explains how imaging technologies accommodate the requirements of the human visual system. The course also explains how image systems simulations can be useful in neuroscience and industrial vision applications.nThe course consists of lectures, software tutorials, and a course project. Tutorials and projects include extensive software simulations of the imaging pipeline. Some background in mathematics (linear algebra) and programming (Matlab) is valuable.nPre-requisite: EE 261 or equivalent. Or permission of instructor required.
Same as: PSYCH 221

SYMSYS 195L. Methods in Psycholinguistics. 4 Units.
Over the past ten years, linguists have become increasingly interested in testing theories with a wider range of empirical data than the traditionally accepted introspective judgments of hand-selected linguistic examples. Consequently, linguistics has seen a surge of interest in psycholinguistic methods across all subfields. This course will provide an overview of various standard psycholinguistic techniques and measures, including offline judgments (e.g., binary categorization tasks like truth-value judgments, Likert scale ratings, continuous slider ratings), response times, reading times, eye-tracking, ERPs, and corpus methods. Students will present and discuss research articles. Students will also run an experiment (either a replication or an original design, if conducive to the student¿s research) to gain hands-on experience with experimental design and implementation in html/javascript and Mechanical Turk; data management, analysis, and visualization in R; and open science tools like git/github.
Same as: LINGUIST 245B

SYMSYS 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, (3) 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/Psychtoolbox 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 created 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 symsys1staff@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 bynhistorians, political scientists, sociologists, and anthropologists, e.g. What are the sources of conflict and disagreement betweennpeople?, What drives or reduces violence and injustice?, and What brings about or is conducive to peace and justice? In this advancednsmall seminar, we will read and discuss works by psychologists, neuroscientists, philosophers, and others, which characterize thisngrowing research area among those who study minds, brains, and behavior.nRequired: 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¿s an apple based on its color and shape? Can 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 290. Master's Degree Project. 1-15 Unit.
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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.

SYMSYS 298. Peer Advising in Symbolic Systems: Practicum. 1-2 Unit.
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.