Cognitive Science

Website: http://cogsci.cas.lehigh.edu/ (http://cogsci.cas2.lehigh.edu/)

The mission of the Cognitive Science Program is to advance the study of minds and brains, real or artificial, in all their aspects, through research and teaching. This interdisciplinary field, encompassing the fields of psychology, linguistics, computer science, philosophy, anthropology, and neuroscience, provides excellent preparation for life in the age of information. The program aims to instill in students a solid grasp of the intellectual problems, frameworks, and methodologies currently available; to provide experience exploring these through guided research; and to foster the desire to create and disseminate new knowledge. With this foundation, students are well prepared for a wide variety of careers at the interfaces of technology, minds, brains, and behavior, and for graduate study in Cognitive Science or any of the contributing disciplines.

We offer undergraduate B.A. and B.S. degrees in Cognitive Science, an undergraduate minor, and a graduate certificate. A Cognitive Science major is easy to combine with a second major in the humanities, natural sciences, social sciences, or computer science.

B.A. IN COGNITIVE SCIENCE

The B.A. in Cognitive Science requires a minimum of 14 courses. All majors take COGS 007, an introduction to cognitive science, plus core courses in cognitive psychology, philosophy, artificial intelligence, and cognitive neuroscience, and collaterals in computer science. They also complete a course in research methods or tools. Students then pursue their individual interests by completing at least five electives from across three tracks. A capstone integration occurs in the required two-semester senior project (COGS 301 and COGS 302, or, for Honors, COGS 391 and COGS 392), in which students focus on a topic of their choice spanning at least two cognitive science sub-disciplines.

Additional coursework in affiliated disciplines is recommended, to be selected in consultation with the major adviser and dependent upon anticipated career path. These courses may fulfill college distribution requirements. Note: A number of major courses have pre-requisites. Students considering this major should check pre-requisites and plan accordingly. A preliminary meeting with the program director may be useful.

Collateral Requirements

CSE 007 Introduction to Programming
or CSE 003 Introduction to Programming, Part A
& CSE 004 and Introduction to Programming, Part B

One course in research methods and tools from the following: PSYC 201 Research Methods and Data Analysis I; PSYC 202 Research Methods and Data Analysis II; ECO 045 Statistical Methods; SOAN 111 Research Methods and Data Analysis; CSE 160 Introduction to Data Science; BIOS 130 Biostatistics

Introductory Course

COGS 007 Introduction to Cognitive Science 4

Disciplinary Core Courses

COGS/PSYC 117 Cognitive Psychology 15
COGS/CSE 127 Survey of Artificial Intelligence
or COGS/CSE 327 Artificial Intelligence Theory and Practice
COGS/PSYC 176 Cognitive Neuroscience
COGS/PHIL 250 Philosophy of Mind
or COGS/PHIL 251 Philosophical Foundations of Cognitive Science

Major Electives 15-20

Select a minimum of five electives, with at least one course from each of the three tracks.

Senior Project 6-8

COGS 301 & COGS 302 Senior Project in Cognitive Science: Proposal and Senior Project in Cognitive Science: Execution Credits may be split between two advisers but must total 3 per semester.

or COGS 391 & COGS 392 Honors Thesis in Cognitive Science: Proposal and Honors Thesis in Cognitive Science: Project Execution and Thesis. Credits may be split between two advisers but must total 4 per semester.

Total Credits 40-47

B.S. IN COGNITIVE SCIENCE

The B.S.in Cognitive Science entails additional courses beyond those in the B.A. to provide both additional breadth and depth. It requires a minimum of 20 courses. All majors take COGS 007, an introduction to cognitive science, plus core courses in cognitive psychology, philosophy, artificial intelligence, and cognitive neuroscience, and collaterals in computer science, math, and social science. They also complete two courses in research methods or tools and at least one semester of supervised research. Students then pursue their individual interests by choosing a concentration area from among three tracks and completing at least six electives with a minimum of four in the concentration area. A capstone integration occurs in the required two-semester senior project (COGS 301 and COGS 302, or, for Honors, COGS 391 and COGS 392), in which students focus on a topic of their choice spanning at least two cognitive science sub-disciplines.

Additional coursework in affiliated disciplines is recommended, to be selected in consultation with the major adviser and dependent upon anticipated career path. These courses may fulfill college distribution requirements. Note: A number of major courses have pre-requisites. Students considering this major should check pre-requisites and plan accordingly. A preliminary meeting with the program director may be useful.

Collateral Requirements 1

MATH 021 Calculus I
or MATH 051 Survey of Calculus I
or MATH 075 Calculus I, Part A
& MATH 076 and Calculus I, Part B

CSE 007 Introduction to Programming
or CSE 003 Introduction to Programming, Part A
& CSE 004 and Introduction to Programming, Part B

CSE 140 Foundations of Discrete Structures and Algorithms
or CSE 160 Introduction to Data Science

PSYC 001 Introduction to Psychology
or ECO 001 Principles of Economics
or ANTH 011 Cultural Diversity and Human Nature

Two courses in research methods and tools.

For Artificial Intelligence and Formal Models Concentration:

CSE 140 Foundations of Discrete Structures and Algorithms
& MATH 231 and Probability and Statistics
or ECO 045 Statistical Methods

For all other concentrations:

PSYC 201 Research Methods and Data Analysis I
or PSYC 202 and Research Methods and Data Analysis II

Introductory Course 4

COGS 007 Introduction to Cognitive Science

Disciplinary Core Course 16
COGS/PSYC 117  Cognitive Psychology
COGS/CSE 127  Survey of Artificial Intelligence  
or COGS/CSE 327  Artificial Intelligence Theory and Practice
COGS/PSYC 176  Cognitive Neuroscience
COGS/PHIL 250  Philosophy of Mind  
or COGS/PHIL 251  Philosophical Foundations of Cognitive Science
COGS 183  Cognitive Neuroscience Recitation  
or COGS 184  Cognitive Neuroscience Recitation

Concentrations  18-24
Choose six electives from the concentration lists, at least four of them from within the same concentration. The lists are the same for the B.A. and the B.S. Requirements specific to each concentration for the B.S. are as follows:

**Artificial Intelligence and Formal Models**
- CSE 017  Programming and Data Structures
- CSE 140  Introduction to Linguistics
- COGS 161  Supervised Research  
- COGS 301  Senior Project in Cognitive Science: Proposal 
  & COGS 302  Senior Project in Cognitive Science: Execution
- Or
  - COGS 391  Honors Thesis in Cognitive Science: Proposal  
  & COGS 392  Honors Thesis in Cognitive Science: Project Execution and Thesis

**Cognitive Neuroscience**
- BIOS 044  Introduction to Integrative and Comparative Biology
- COGS 391  Honors Thesis in Cognitive Science: Proposal  
  & COGS 392  Honors Thesis in Cognitive Science: Project Execution and Thesis

Total Credits  46-56

1 Collateral courses may count toward CAS distribution requirements where applicable.
2 BIOS 044 pre-reqs: any CHM course that fulfills the pre-requisite for BIOS 041, plus BIOS 041 Introduction to Cellular and Molecular Biology and BIOS 042 Introduction to Cellular and Molecular Biology Laboratory. These are not part of the major but can count toward CAS Natural Science distribution.
3 Students are encouraged to take the required research credits beginning in the second year or even earlier. At least two semesters of relevant research experience (minimum 4 credits) are required for B.S. students prior to enrolling in COGS 391 Honors Thesis in Cognitive Science: Proposal and COGS 392 Honors Thesis in Cognitive Science: Project Execution and Thesis for their senior project.
4 May be repeated for credit.
5 Credits may be split between two advisers but must total 3 per semester (301,302) or 4 per semester (391, 392).
6 Not available in the Artificial Intelligence concentration.
7 This option is not available in the Artificial Intelligence concentration.

**MAJOR ELECTIVES**

**Artificial Intelligence and Formal Models**
- CSE 017  Programming and Data Structures
- CSE 042  Game Design
- CSE 140  Foundations of Discrete Structures and Algorithms
- CSE 262  Programming Languages
- CSE 318  Introduction to the Theory of Computation
- CSE 326  Fundamentals of Machine Learning
- CSE 331  User Interface Systems and Techniques
- CSE 335  Topics on Intelligent Decision Support Systems
- CSE 337  Reinforcement Learning
- CSE 347  Data Mining
- CSE 348  AI Game Programming
- CSE 360  Introduction to Mobile Robotics
- CSE 428  Semantic Web Topics
- CSE 431  Intelligent Agents
- PHIL/MATH 014  Symbolic Logic
- PHIL/MATH 114  Metalogic
- PHIL/MATH 214  Topics in Philosophical Logic
- PHIL 265  Philosophy of Mathematics

**Cognition, Culture, and Meaning**
- COGS/ANTH/MLL 140  Introduction to Linguistics
- CSE 252  Computers, the Internet, and Society
- EDUC 391  Educational Linguistics
- JOUR 135  Human Communication
- PHIL 128  Philosophy Of Science
- PHIL 135  Modern Philosophy
- PHIL 139  Contemporary Philosophy
- PHIL 220  Epistemology
- PHIL 228  Philosophy of Specific Sciences
- PHIL 260  Philosophy of Language
- PSYC 307  Higher Order Cognition
- PSYC 313  Person Perception
- PSYC 314  Social Cognition
- PSYC/HMS 344  Health Care Reasoning and Decision Making
- PSYC 351  Children's Thinking
- PSYC/EVST 357  Psychology of Environmental Issues
- PSYC 362  Cognition in Practice & Policy
- PSYC/GE 365  Human Development in Cross-Cultural Perspective
- PSYC 376  Child Language and Social Inequality
- PSYC 384  Self and Identity
- SOC 118  Sociology of Culture
- SOC 336  Computational Text Analysis

**Cognitive Neuroscience**
- ANTH 012  Intro to Archaeology and Human Origins
- BIOS 044  Introduction to Integrative and Comparative Biology
- ANTH 145  Human Evolution
- BIOS 276  Central Nervous System and Behavior
- BIOS 277  Experimental Neuroscience Laboratory
- BIOS 332  Behavioral Neuroanatomy
- BIOS 365  Neurobiology of Sensory Systems
- BIOS 366  Diseases of the Nervous System
MINOR IN COGNITIVE SCIENCE
The undergraduate minor in Cognitive Science requires five courses:

COGS 007  Introduction to Cognitive Science  4  
Four additional courses selected from among the major's core courses and major electives, with at least two of these being Disciplinary Core Courses

Total Credits  16-20

PROGRAM HONORS
Majors seeking to graduate with honors in cognitive science must have a 3.30 GPA in the major, a 3.30 GPA overall, and complete a high quality senior thesis with enrollment in COGS 391 Honors Thesis in Cognitive Science: Proposal and COGS 392 Honors Thesis in Cognitive Science: Project Execution and Thesis. Theses submitted for honors will be evaluated by a committee of at least three cognitive science faculty.

GRADUATE CERTIFICATE IN COGNITIVE SCIENCE
The graduate certificate provides the opportunity to develop an interdisciplinary perspective on human and machine intelligence. It is available to both enrolled and external students.

Students in Lehigh University graduate degree programs such as computer science, psychology, and instructional technology are encouraged to participate with the approval of an adviser in the program. External candidates will also need to apply to the College of Arts and Sciences for non-degree graduate status.

The certificate will appear on the student's transcript after submission of a signed completion form by the program director.

The Graduate Certificate requires four courses from the list below. At least two of the courses must be outside the home department. The certificate will entail 12-16 credits.

ELECTIVES

<table>
<thead>
<tr>
<th>Courses</th>
<th>Credits</th>
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<tbody>
<tr>
<td>CSE 327  Artificial Intelligence Theory and Practice</td>
<td>3</td>
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<td>CSE 331  User Interface Systems and Techniques</td>
<td>3</td>
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<tr>
<td>CSE 335  Topics on Intelligent Decision Support Systems</td>
<td>3</td>
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<td>CSE 348  AI Game Programming</td>
<td>3</td>
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<td>CSE 409  Theory of Computation</td>
<td>3</td>
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<tr>
<td>CSE 426  Fundamentals of Machine Learning</td>
<td>3</td>
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<td>CSE 428  Semantic Web Topics</td>
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<td>CSE 431  Intelligent Agents</td>
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<tr>
<td>CSE 435  Topics on Intelligent Decision Support Systems</td>
<td>3</td>
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<tr>
<td>CSE 437  Reinforcement Learning and Markov Decision Processes</td>
<td>3</td>
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<td>CSE 447  Data Mining</td>
<td>3</td>
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<td>CSE 460  Mobile Robotics</td>
<td>3</td>
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<td>Psychology</td>
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<td>PSYC 307  Higher Order Cognition</td>
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<td>PSYC 313  Person Perception</td>
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<td>PSYC 314  Social Cognition</td>
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<td>PSYC 316  The Talking World: Psychology and Neuroscience of Speaking</td>
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<td>PSYC 320  Health Care Reasoning and Decision Making</td>
<td>3</td>
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<td>PSYC 347  Cognitive Neuroscience of Memory</td>
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<td>PSYC 351  Children's Thinking</td>
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<td>PSYC 355  Seminar in Cognitive Neuroscience</td>
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<td>PSYC 358  Cognitive Psychology</td>
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<td>PSYC 362  Developmental Psychology</td>
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<td>PSYC 377  Cognitive Neuroscience Techniques</td>
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<td>PSYC 402  Seminar in Psychology of Language</td>
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<td>PSYC 403  Social Cognition</td>
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<td>PSYC 433  Ontological Psychology</td>
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<td>PSYC 448  Seminar in Cognitive Development</td>
<td>3</td>
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<td>PSYC/COGS 478  Cognitive Neuroscience Techniques</td>
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<td>PSYC 464  Seminar in Cognition</td>
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<td>PHILO/COGS 250  Philosophy of Mind</td>
<td>3</td>
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<td>PHIL 260  Philosophy of Language</td>
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<tr>
<td>Sociology and Anthropology</td>
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Total Credits  1

Note: These particular 200-level courses may be taken by graduate students.

Courses
COGS 007  Introduction to Cognitive Science  4 Credits
What is a mind? How is the mind related to the brain? Could we make an artificial mind? Issues concerning knowledge representation and intelligence in minds and computers as investigated by psychologists, philosophers, linguists, neuroscientists, and researchers in artificial intelligence.

COGS 091  Special Topics  1-4 Credits
Intensive study of a topic of special interest not covered in other courses.
Repeat Status: Course may be repeated.
Attribute/Distribution: HU, SS

COGS 098  1-4 Credits
Repeat Status: Course may be repeated.

COGS 117  Cognitive Psychology  4 Credits
The architecture and dynamics of the human mind: How we acquire knowledge through perception, represent and activate it in memory, and use it to communicate, make decisions, solve problems, and reason creatively. May not be taken pass/fail.
Prerequisites: PSYC 001 or COGS 007
Attribute/Distribution: SS

COGS 127  Survey of Artificial Intelligence  3 Credits
An introduction to artificial intelligence (AI) intended for non-majors. AI concepts, systems, and history. Credit will not be given for both CSE/COGS 127 and CSE/COGS 327.
Prerequisites: CSE 002 or CSE 004 or CSE 007
<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
<th>Credits</th>
<th>Prerequisites</th>
<th>Repeat Status</th>
<th>Attribute/Distribution</th>
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<tbody>
<tr>
<td>COGS 140</td>
<td>Introduction to Linguistics</td>
<td>4</td>
<td></td>
<td>Course may be repeated</td>
<td>HU, SS</td>
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<td></td>
<td></td>
<td></td>
<td>Relationship between language and mind; formal properties of language; language and society; how languages change over time. May not be taken pass/fail.</td>
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<td>COGS 161</td>
<td>Supervised Research</td>
<td>1-3</td>
<td>Research under the direct supervision of a faculty member in the cognitive science program. Students must arrange the particular project with a faculty member before enrolling. Consent of program director required.</td>
<td>Course may be repeated</td>
<td>ND</td>
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<td>COGS 176</td>
<td>Cognitive Neuroscience</td>
<td>4</td>
<td>Perception and cognitive neuroscience as the link between mental processes and their biological bases. Visual and auditory perception; the control of action; neuropsychological syndromes of perception, language, memory, and thought; neural network (connectionist) models of mental processes. May not be taken pass/fail.</td>
<td>Course may be repeated</td>
<td>ND</td>
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<td>COGS 183</td>
<td>Cognitive Psychology Recitation</td>
<td>1</td>
<td>Research, discussion, and analysis of topics in cognitive psychology.</td>
<td>Course may be repeated</td>
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<tr>
<td>COGS 184</td>
<td>Cognitive Neuroscience Recitation</td>
<td>1</td>
<td>Research, discussion, and analysis of topics in cognitive neuroscience.</td>
<td>Course may be repeated</td>
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<tr>
<td>COGS 191</td>
<td>Special Topics</td>
<td>1-4</td>
<td>Intensive study of a topic of special interest not covered in other courses.</td>
<td>Course may be repeated</td>
<td>HU, SS</td>
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<td>COGS 250</td>
<td>Philosophy of Mind</td>
<td>4</td>
<td>An exploration of the mind-body problem. Are the body and mind distinct substances (dualism); or is there only body (materialism); or only mind (idealism)? Other views to be considered include behaviorism (the view that behavior can be explained without recourse to mental states), and the view that the mind is a complex computer. Student must have completed at least one Philosophy course at the 100-level.</td>
<td>Course may be repeated</td>
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<tr>
<td>COGS 251</td>
<td>Philosophical Foundations of Cognitive Science</td>
<td>4</td>
<td>Cognitive Science is the study of aspects of natural and artificial minds: perception, cognition, reasoning, action, and language. Several fields intersect here: artificial intelligence, linguistics, cognitive psychology, philosophy, and neuroscience. Central issues include: the nature of representation, the boundaries of cognitive science, and consciousness. We will survey the foundational philosophical aspects of these issues within Cognitive Science. Student must have completed at least one Philosophy course at the 100-level, or major in Cognitive Science.</td>
<td>Course may be repeated</td>
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<td>COGS 291</td>
<td>Special Topics</td>
<td>1-4</td>
<td>Intensive study of a topic of special interest not covered in other courses.</td>
<td>Course may be repeated</td>
<td>HU, SS</td>
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<td>COGS 300</td>
<td>Apprentice Teaching</td>
<td>1-4</td>
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<td>COGS 301</td>
<td>Senior Project in Cognitive Science: Proposal</td>
<td>1-3</td>
<td>For students not intending to apply for program Honors. Background reading and preparation of a short written proposal are conducted in the first semester in consultation with a faculty adviser. Students must enroll for a total of three credits which may be split between the sections of a primary and secondary adviser. Consent of program director and project adviser required.</td>
<td>Course may be repeated</td>
<td>ND</td>
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<td>COGS 302</td>
<td>Senior Project in Cognitive Science: Execution</td>
<td>1-3</td>
<td>For students not intending to apply for program Honors. Execution of the project is conducted in the second semester in consultation with a faculty adviser. A presentation will be given at the end of the semester. Students must enroll for a total of three credits which may be split between the sections of a primary and secondary adviser. Consent of program director and project adviser required.</td>
<td>Course may be repeated</td>
<td>ND</td>
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<td>COGS 327</td>
<td>Artificial Intelligence Theory and Practice</td>
<td>3</td>
<td>Detailed analysis of a broad range of artificial intelligence (AI) algorithms and systems. Problem solving, knowledge representation, reasoning, planning, uncertainty and machine learning. Applications of AI to areas such as natural language processing, vision, and robotics. Credit will not be given for both CSE/COGS 127 and CSE/COGS 327.</td>
<td>Course may be repeated</td>
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<td>COGS 361</td>
<td>Independent Research</td>
<td>2-4</td>
<td>Independent research in cognitive science with a faculty advisor. Students must arrange the particular project with a faculty advisor before enrolling. Consent of program director required.</td>
<td>Course may be repeated</td>
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<td>COGS 391</td>
<td>Honors Thesis in Cognitive Science: Proposal</td>
<td>1-4</td>
<td>For students with 3.3 or higher major and overall GPA by the spring of the junior year, who want to undertake a project with the potential for program Honors. Literature review and preparation of a written proposal are conducted in the first semester in consultation with a faculty adviser. An oral presentation will be given at end of the semester. Students must enroll for four credits which may be split between co-advisers. Consent of program director and project adviser required.</td>
<td>Course may be repeated</td>
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<td>COGS 392</td>
<td>Honors Thesis in Cognitive Science: Project</td>
<td>1-4</td>
<td>For students with 3.3 or higher major and overall GPA by the spring of the junior year. Project execution and preparation of the written report is conducted in the second semester. An oral presentation will be given at the end of the semester. Theses will be evaluated for Honors by three cognitive science faculty. Students must enroll for a total of four credits which may be split between co-advisers. Consent of program director and project adviser required.</td>
<td>Course may be repeated</td>
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<td>COGS 394</td>
<td>Special Topics in Cognitive Science</td>
<td>3-4</td>
<td>Topics vary from semester to semester. Topics are presented at an advanced level.</td>
<td>Course may be repeated</td>
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<td>COGS 405</td>
<td>Individual Study in Cognitive Science</td>
<td>1-6</td>
<td>Study of a topic not covered in regular course offerings. By arrangement with a consulting faculty member. Consent of program director required.</td>
<td>Course may be repeated</td>
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COGS 423 (PSYC 423) Foundations of Cognitive Science 3 Credits
Survey of fundamental theory and methodologies from artificial intelligence, linguistics, cognitive psychology, philosophy, and neuroscience, as well as salient research problems such as knowledge acquisition and representation, natural language processing, skill acquisition, perception and action, and the philosophical question of intentionality.

COGS 478 (PSYC 478) Ontological Psychology 3 Credits
Principles and constraints for modeling psychological phenomena. Representation; perception; memory; knowing; learning; emotions; consciousness; language; rationality.